INDEX FOSSILS OF NORTH AMERICA

A NEW WORK BASED ON THE COMPLETE REVISION AND REILLUSTRATION OF

GRABAU AND SHIMER'S
"NORTH AMERICAN INDEX FOSSILS"

BY

HERVEY W. SHIMER
Professor Emeritus of Paleontology
Massachusetts Institute of Technology

AND

ROBERT R. SHROCK
Associate Professor of Geology
Massachusetts Institute of Technology

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Dedicated to

AMERICAN PALEONTOLOGISTS

Who, in giving largely of their time, energy, and knowledge, endowed this work with merit and authenticity which it otherwise could not have possessed.

PREFACE

The original edition of Grabau and Shimer's *North American Index Fossils* was stated by its authors to be ". . . essentially a treatise on . . . those fossils best adapted for the determination of geologic horizons." Its aim was to make it possible, in both field and laboratory, to identify faunas and to correlate strata. Furthermore, it was hoped that it might serve as a textbook of invertebrate paleontology. In short, the book was designed specifically for the investigator of stratigraphic paleontology.

The present work, while resembling the original in general purpose, form, and content, and retaining essentially the same title, differs from the first edition in so many ways and to such a great extent that it should properly be considered a new work. We shall not, therefore, follow the usual practice in revisions of repeating the preface to the earlier edition.

This book is largely the work of Hervey W. Shimer and Robert R. Shrock; certain portions, however, were contributed by colleagues. These contributions are specifically credited to their authors. Dr. Grabau, senior author of the first edition, and A. G. Seiler, New York, publisher of *North American Index Fossils*, both graciously relinquished their royalty rights in the new work and granted the revising authors permission to revise the book along such lines as they might determine. Dr. Grabau did not participate in the revision and hence should not be held responsible for any deviations from the first edition.

The new revised work has been underwritten by the Massachusetts Institute of Technology as a Technology Press Publication and is to be distributed by John Wiley & Sons, Inc. Under this agreement the authors have assigned all royalties to The Technology Press to help defray the cost of publication. An announcement of this general plan was noticed in the *Journal of Paleontology* for May 1940, where the hope was expressed that the revision might be completed in two years.

Calls to our many colleagues for assistance elicited prompt and cordial responses, and the finished work stands as an example of the finest type of scientific cooperation and collaboration.

Our greatest single indebtedness is to the Massachusetts Institute of Technology for underwriting the publication of this book and for authorizing its issuance under the imprint of The Technology Press.

We wish also to record our great debt to Dr. Warren J. Mead, Chairman of the Department of Geology of the Massachusetts Institute of Technology, who not only supported and maintained sympathetic interest in the project of revision but also always seemed to find the financial assistance unexpectedly needed at times to complete some phase of the project.

American paleontologists responded in a most heartening way to the multitude of requests put to them by us during the period of revision, and it is a pleasant duty, now in a general way and later in a specific way, to credit our colleagues in full measure for their indispensable assistance.

Some parts of the book represent original contributions, and we have not modified this material except to make it conform with the general plan. Such contributions carry the credit line "Prepared by," followed by the name or names of the authors. Certain divisions of the book, after preliminary revision by us, were thoroughly revised by one or more specialists. Such revision is largely the work of the specialists, particularly in those instances where they furnished some or all of the illustrations. Those divisions carry the credit line "Revised by," followed by the name or names of the revisers. The various divisions were contributed or revised as indicated below:

PROTOZOA (Foraminifera), prepared by Joseph A. Cushman, Lloyd G. Henbest, and W. Storrs Cole.
ECHINODERMA (Blastoidea), revised by Lewis M. Cline.
ECHINODERMA (Crinoidea), prepared by Raymond C. Moore and Lowell R. Laudon.
CONODONTS, prepared by Edwin B. Branson and Maurice G. Mehl.
BRACHIOPODA, prepared by G. Arthur Cooper.
MOLLUSCA (Paleozoic Gastropoda), revised by J. Brookes Knight, with the collaboration of Josiah Bridge and the authors.
ARTHROPODA (Insecta), prepared by Frank M. Carpenter.
CHAROPHYTA, prepared by Raymond E. Peck.
CALCAREOUS ALGAE, prepared by J. Harlan Johnson.

Hardly any large division of the text matter escaped examination by one or more specialists and in many divisions half a dozen colleagues contributed data and occasional illustrations. All such contributions served a definite purpose, but lack of space prohibits specific acknowledgements here. Full acknowledgments are made, however, in a footnote immediately following the introduction to the particular division or in the plate captions.

We cannot forbear mentioning our special indebtedness to several individuals who contributed so much to the revision. Dr. R. S. Bassler was a constant source of assistance and advice to the junior author during his several periods of work at the U. S. National Museum. Dr. P. E. Raymond placed his large library of reprints at the junior author's disposal and many times served in an advisory capacity. Dr. C. O. Dunbar granted us the use of a laboratory manual of "index fossils" which he and his students had assembled, and he assisted us in several other ways. Drs. Winifred P. Goldring, C. G. Croneis, U. S. Grant IV, and B. F. Howell were most helpful in answering numerous questions and particularly in obtaining for us certain publications and illustrations.

We are grateful to Mr. Wm. E. Schevill, Librarian of the Museum of Comparative Zoology, Harvard University, and to his library staff, particularly Miss Alice Egan and Miss Jane R. Gold, who on many occasions were most helpful, especially to the junior author. We owe an additional debt to Dr. Thomas Barbour, Director of the Museum of Comparative Zoology, for permission to borrow many volumes from which illustrations were copied. Miss Grace Bogart, Librarian of the Lindgren Library of the Massachusetts Institute of Technology, constantly aided us in locating and procuring desired volumes.

The generous manner in which North American geological surveys and scientific periodicals have illustrated their publications has made possible the full illustration of the present work. Constant and rather extensive use of these publications has been made with full confidence that authors and editors would sanction such practice. Sources of text matter are listed in the numerous divisional bibliographies; illustrations are credited to the proper sources in the plate captions.

Mr. Richard E. Pope, Commercial Photographer at the Massachusetts Institute of Technology, deserves an expression of gratitude for his continuous efforts to produce the best possible copy for the illustrations.

Efficient typing and editorial work by Mrs. Willis V. Ames in the early part of the revision and by Mrs. Kirk Stephenson during preparation of the final typescript relieved us of an onerous task. The large amount of necessary correspondence was handled efficiently by the secretarial staff of the Department of Geology of the Massachusetts Institute of Technology.

We are grateful to Florence Henry Shimer and Theodora Weidman Shrock, both of whom were called upon many times for help in checking and in editorial matters.

Finally, there is no adequate way of acknowledging the assistance we have received directly or indirectly from dozens of colleagues who have sent us illustrations and reprints, written their suggestions, or spoken their ideas to us in hundreds of discussions. To all these, and to all others who in any way contributed to the present work, we would render grateful acknowledgments and would ask that they consider themselves included in the dedicatory lines.

HERVEY W. SHIMER
ROBERT R. SHROCK

CAMBRIDGE, MASS.
July 1, 1943

CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
	General Statement	1
	What is an Index Fossil?	1
	Description of Genera and Species	2
	Illustrations	4
	References	5
	Key to Abbreviations and Symbols Used in Text, References, and Plate Captions	8
II.	PHYLUM PROTOZOA	11
	Class Mastigophora	11
	Class Sarcodina	12
	Order Foraminifera (Prepared by Joseph A. Cushman, Lloyd G. Henbest, and W. Storrs Cole)	12
	Order Radiolaria	48
III.	PHYLUM PORIFERA	49
	Class Silicispongiae	51
	Isolated Siliceous Spicules	56
	Class Calcispongiae	56
	Class Pleospongia (Archaeocyathids)	56
	Sponge Borings	57
	Porifera Incertae Sedis	57
IV.	PHYLUM COELENTERATA	58
	Class Hydrozoa	58
	Class Stromatoporoidea	58
	Class Graptozoa	64
	Class Scyphozoa	77
	Class Anthozoa	79
V.	PHYLUM ECHINODERMA	123
	Subphylum Pelmatozoa	123
	Class Cystoidea	123
	Class Edrioasteroidea	129
	Class Blastoidea (Revised by Lewis M. Cline)	133
	Class Crinoidea (Prepared by Raymond C. Moore and Lowell R. Laudon)	137
	Subclass Inadunata	143
	Subclass Flexibilia	177
	Subclass Camerata	183
	Subclass Uncertain	205
	Fragmentary Remains	207
	Subphylum Eleutherozoa	211
	Class Stelleroidea	211
	Class Echinoidea (including echinoid elements as guide fossils)	226
	Class Holothuroidea	227
VI.	WORMS	228
	PHYLUM ANNELIDA (ANNULATA)	228
	Class Chaetopoda	229
	Class Sipunculoidea (Gephyrea)	234

CHAPTER PAGE

VII. CONODONTS (Prepared by Edwin B. Branson and Maurice G. Mehl) 235

VIII. PHYLUM BRYOZOA (POLYZOA) 247
Order Ctenostomata 249
Order Cyclostomata 250
Order Trepostomata 255
Order Cryptostomata 261
Order Cheilostomata 271

IX. PHYLUM BRACHIOPODA (Prepared by G. Arthur Cooper) 277
Introduction 277
Class Inarticulata 281, 284
Order Atremata 284
Order Neotremata 287
Class Articulata 282, 293
Order Palaeotremata 293
Impunctate Articulata 293
Pseudopunctate Articulata 335
Punctate Articulata 351

X. PHYLUM MOLLUSCA 366
Class Pelecypoda (Lamellibranchiata) 367
Order Prionodesmacea 369
Order Anomalodesmacea 413
Order Teleodesmacea 415
Class Gastropoda 433
Paleozoic Gastropoda (Revised by J. Brookes Knight, with collaboration of Josiah Bridge and the authors) 437
Subclass Protogastropoda 437
Subclass Eugastropoda 439
Superorder Prosobranchia 439
Mesozoic to Recent Gastropoda 479
Superorder Prosobranchia 479
Superorder Opisthobranchia 515
Order Tectibranchiata 515
Order Pteropoda 517
Superorder Pulmonata 519
Class Scaphopoda 521
Mollusca Incertae Sedis 523
Class Amphineura 526
Class Cephalopoda 527
Subclass Nautiloidea 529
Subclass Ammonoidea 563
Subclass Coleoidea (Dibranchia) 595

XI. PHYLUM ARTHROPODA 599
Class Crustacea 599
Subclass Agnostia 600
Subclass Trilobita 601
Lower and Middle Cambrian Trilobita 605
Upper Cambrian Trilobita 619
Post-Cambrian Trilobita 635
Subclass Homopoda 655
Subclass Xenopoda 655
Subclass Archaeostraca 655
Archaeostraca Incertae Sedis 659
Subclass Branchiopoda 659
Subclass Ostracoda 660
Subclass Cirripedia 693

CHAPTER PAGE

Subclass Malacostraca 695
Crustacea Incertae Sedis 701
Class Myriapoda 701
Class Insecta (Prepared by Frank M. Carpenter) 701
Class Arachnida 703
Subclass Merostomata 705
Subclass Embolobranchiata 709

XII. FOSSIL PLANTS 711
Diatomaceae 712
Charophyta (Prepared by Raymond E. Peck) 712
Calcareous Algae (Prepared by J. Harlan Johnson) 716
Miscellaneous Algae 716

MISCELLANEOUS OBJECTS OF PROBABLE ORGANIC ORGIN 717

INDEX 721

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

This introductory chapter has been prepared to acquaint the reader with the purpose of the present work, the nature and method of presentation of its contents, the sources from which descriptive matter and illustrations were obtained, and the extent to which contributions and revisions were made by our colleagues.

The primary purpose of this work, as of the first, is to describe and illustrate as many as possible of those fossils which can be used to identify and date formations and to correlate them from one area to another. Consequently, the genera and species here considered have been selected because of their proved or suspected usefulness in identifying and correlating strata.

Some fossils, so far as present records go, are rare and restricted to a few localities, but if a genus is known to occur in Newfoundland and Nevada, or in northern Vermont and the Argentine, it is almost certain to turn up elsewhere. A number of such genera are considered. Genera known to have a short vertical range have been included. Some genera with long vertical ranges have been selected, not because of any particular value as index fossils but because they are common. The investigator should know what is useless and not send such material to specialists. Many recently described genera and species have been included despite the fact that their worth as index fossils has not yet been tested. Some of them are certain to be of importance in the future. A few other genera have been selected merely to round out the general picture of invertebrate fossils. It has been thought proper to give some representatives of each of the main taxonomic groups which may be encountered in the field, so that the collector who happens on unusual or peculiar specimens may get at least a general idea of what his material is.

The order in which the phyla are considered is arbitrary and was chosen for practical reasons alone. Likewise, we have departed in some instances from the generally accepted taxonomic arrangement of phyletic divisions, again for practical reasons. Such departures are considered justifiable because the present work is not primarily taxonomic or genetic in its general plan or purpose.

A small section on fossil plant structures and miscellaneous probable fossils is added in Chapter XII. These interesting forms are often encountered by invertebrate paleontologists; hence a brief consideration of a few of them seems justified.

In general, a brief introduction precedes systematic description of genera and species. This introductory discussion has been made brief purposely, except in a few instances (Crinoidea, Brachiopoda, Ostracoda), because the reader is assumed to have a general knowledge of invertebrate paleontology or to have readily available one of the standard textbooks on the subject. Several textbooks are listed under "References" elsewhere in this chapter.

WHAT IS AN INDEX FOSSIL?

Definition. An index fossil is one which identifies and dates the strata or succession of strata in which it lies. The ideal index species has narrow or restricted stratigraphic range and broad, even worldwide, geographic distribution. Such species are not common, however, if the entire geologic column is considered. A genus which has narrow stratigraphic range and rather broad geographic distribution is now considered an index fossil. Most correlations by mollusks and arthropods are based on genera rather than on species, mainly because genera can be more easily differentiated than species. Worldwide distribution of certain genera of fusulinids, corals, cephalopods, and trilobites makes generic differentiation extremely important.

Form Species. A "form species" may be defined as a group of closely related species, all of which possess essentially similar characteristics but vary each from the others in features now considered to be of about varietal value. Examples are *Stromatopora antiqua*, *Favosites favosus*, *Leptaena rhomboidalis*, *Productus punctatus*, *Atrypa reticularis*, *Calymene niagarensis*, and *Isotelus gigas*.

Recently Ulrich and Resser (1930, 1–58) split the well-known "form species" *Dikelocephalus minnesotensis* into 25 distinct species. Since all of the specimens came from a rather small area and from the same general horizon, the ordinary paleontologist or stratigrapher probably would prefer to use the old form species in its broad meaning, rather than try to differentiate the numerous species which do not appear greatly different except to the highly trained eye of the specialist.

Form Genus. In describing certain genera we have used the term "form genus" in three different senses. It may be used for a series of related genera which have resulted from the splitting up of an old familiar genus, as *Fusulina*, *Aulopora*, *Productus*, *Platyceras*, and *Dikelocephalus*. It may be used for a complex of genera which are known to be distinct but which have not as yet been named because all have the same general habit. Examples are *Tetra-*

graptus and *Monograptus*. Finally, the term is a general designation for the residuum after a genus has been partly revised. Examples are *Zaphrentis*, *Orthoceras*, and *Calymene*.

The old names of form genera will probably have to be abandoned sooner or later, but adjectives derived from them will continue to be very useful in stratigraphic paleontology (e.g. fusulinid, productid, agnostid).

Fossils with Restricted Distribution. The usual index fossils are somewhat restricted in geographic distribution and are likely to range through a considerable thickness of strata. These are nonetheless valuable for intra-continental and geosynclinal or provincial correlation. Even species and genera restricted to a single basin or trough of deposition may prove useful in correlating overlapping and interfingering lithologic facies.

Fragmental Index Fossils. Fragmental remains may serve very effectively as index fossils, even if the exact nature of the organism or of the "skeletal" hard parts is unknown. Conodonts and scolecodonts have been used in this way, despite the controversial nature of the first, or the fact that complete assemblages of either are exceedingly rare. Sponge spicules may have a limited use, and crinoid and echinoid fragments have been receiving considerable attention in recent years. Microscopic fossils, other than Foraminifera and Ostracoda, particularly silicified forms, regardless of whether they represent complete or fragmental parts, are sure to become increasingly important in the future. Radiolaria, microcrinoids, microbrachiopods, microtrilobites, and the silicified early growth stages of certain groups all deserve continued investigation.

Heterogeneous Index Fossils. Finally, there is a large heterogeneous group into which certain index fossils are gathered because they can not be related to any known or extinct organisms. This group, which is merely a "catch-all," contains a variety of tracks, trails, markings, borings, and similar nondescript evidences of organic activity. For many years the terms "worm trail" and "fucoid" were convenient labels for such fossils, some of which were used locally for correlation with considerable success.

Summary. This book contains examples of all the types of index fossils just described, and it is believed that each, in its own way, may be of some importance in the proper place and under the proper circumstances.

Identifications and correlations should always, of course, be based on a large and well preserved assemblage of characteristic fossils, but that situation is too infrequently encountered in actuality. More often the paleontologist has only a few fairly well preserved specimens, and frequently he may have to determine the identity of a fossil or the age of a formation by means of a few scraps and fragments which have escaped destruction by scavengers, diagenesis, recrystallization, or weathering. The accuracy of species and age determinations is a function of the state of preservation of the fossils; conclusions based on fossils, therefore, need to be evaluated with these factors in mind.

Judicial use of the illustrations should help the paleontological investigator toward identifying and dating his fossils; but if precise determinations are required, an adequate library will be necessary and the present work can then only serve as a guide for further research.

DESCRIPTION OF GENERA AND SPECIES

General Statement. A definite plan is followed in presenting information concerning genera and species, and there is deviation only in special cases where some other method of treatment is considered more appropriate.

Genera usually are described in taxonomic order (by family, superfamily, or ordinal groupings), with the divisions having the oldest fossil representation coming first. In some instances, however, strict taxonomic grouping was not followed for one reason or another. As an example, the trilobite genera are arranged alphabetically under several subheads because no satisfactory taxonomic grouping has yet been proposed.

Species usually are considered in stratigraphic order, the oldest first and the youngest last; and by geographic area, from north to south and from east to west.

The preferred generic name, together with the author and date, appears as a center head. Other names that have been used follow in parentheses.

At the beginning of the generic description is the genotype inclosed in parentheses and italicized. The description itself is brief and telegraphic, with related or correlative data set off by semicolons (;).

Geologic range is indicated by geologic periods, or parts of periods, in boldface. In many instances geographic distribution data follow, inclosed in parentheses.

Each specific name, in boldface, following the initial letter of its genus, is indented. Next comes the authorship, followed by the plate and figure numbers inclosed in parentheses. In most instances species are not described, but if they are, the description is brief. Age and distribution data complete the discussion.

Each aspect of this general plan will now be discussed fully so that the investigator who is using this work will understand and appreciate the necessarily condensed form in which the information is presented and will, as a consequence, derive the maximum benefit from the context.

Generic Name. Considerable effort has been made to determine the preferred generic name, as well as the correct spelling, authorship, and date when it was proposed. We have followed as faithfully as possible the laws proposed by the Committee on International Zoological Nomenclature, and in the few instances where we have departed from this practice, it has usually been because continued *de facto*

usage will cause much less confusion than resurrection of *de jure* proposals.

Many publications were consulted to obtain the pertinent information on the generic names. The following references have been the main source of information concerning them, especially as regards spelling, authors who erected or modified original generic names, and dates when genera were first described. The present authors have made no attempt to consult most original descriptions. This is particularly true as regards the older genera.

NOMENCLATOR ZOOLOGICUS, A list of the names of genera and subgenera in zoology from the tenth edition of Linnaeus 1758 to the end of 1935, S. A. Neave, published by the Zoological Society of London, Vol. I, A–C, 1939; Vol. II, D–L, 1939; Vol. III, M–P, 1940; Vol. IV, Q–Z, 1940.

NOMENCLATOR ANIMALIUM GENERUM ET SUBGENERUM, im Auftrage der Preussischen Akademie der Wissenschaften zu Berlin [1758–1922]; Herausgegeben von F. E. Schulze, W. Kükenthal, fortgesetzt von K. Heider und R. Hesse, Schriftleiter Th. Kuhlgatz, Band 1, A–B, 1926; Band 2, C–E, 1929; Band 3, F–M, 1932; Band 4, N–P, 1935; Band 5, Q–Z, *incomplete*.

INDEX ANIMALIUM, sive index nominum quae ab A. D. MDCCCLVIII generibus et speciebus animalium imposita sunt [1758–1850], C. D. Sherborn; Cantabrigiae E Typographio Academico 1750–1800, A–Z, 1902; 1801–1850, 9 vols., 1922–1932. Supplement zu C. D. Sherborns Index Animalium, by Franz Poche, Festschrift zum 60 Geburtstage von Professor Dr. Embrik Strand, Vol. 5: 477–615, 1939.

ZOOLOGICAL RECORD, compiled and published by the Zoological Society of London, Vols. 1–75, 1864–1938, inclusive.

NOMENCLATOR ZOOLOGICUS, An alphabetical list of all generic names that have been employed by naturalists for recent and fossil animals from the earliest times to the close of the year 1879; Pt. I, Supplemental List, p. 1–376, 1882; Pt. II, Universal Index, p. 1–340, 1884, S. H. Scudder, *USNM*, B 19, 1882–1884.

NOMENCLATOR ZOOLOGICUS, continens nomina systematica generum animalium tam viventium quam fossilium, secundum ordinem alphabeticum disposita [1842–1868], Sub auspiciis et sumptibus C. R. Societatis Zoologico Botanicae, Conscriptus A. Comite Augusto de Marschall, Vindobonae, 1872.

An Index to the generic and trivial names of animals, described by Linnaeus, in the 10th and 12th editions of his "SYSTEMAE NATURAE," C. D. Sherborn, The Manchester Mus. Pub. 25, 1899, p. 1–108.

FOSSILIUM CATALOGUS I, Animalia, Pars. 1–89, 1913–1939, W. Junk, Berlin and The Hague.

In addition to these, there are numerous indexes and similar lists of genera, subgenera and species which are more restricted in the taxonomic divisions and geologic time intervals that they cover. These are discussed briefly under "References" and are listed in the appropriate bibliographies throughout the book.

Students beginning the study of paleontology should be cautioned in the use of these and other similar compilations because authors differ in the way they treat certain controversial problems. Furthermore, any compilation, the present one not excepted, is certain to perpetuate errors because of the necessity of accepting "authority." It would have been impossible to check the original description of each genus used in the present work and still complete the task within a reasonable time. We have made every effort to verify all proposals concerning which questions arose, and if the information here given is not complete, we can only beg the forbearance of our colleagues.

Generic names which are listed as synonyms, in parentheses immediately after the preferred name, have been obtained from standard works or have been suggested by specialists who assisted in revision. These names are listed chronologically, and their order has no other significance.

If genera as such are illustrated, the plate and figure numbers in parentheses follow the date of the genus.

Genotypes. The genotype as it was proposed originally is indicated by an asterisk (*) and italics and is inclosed in parentheses immediately before the generic description. Elsewhere in the text it may be in italics or boldface, and usually it does not carry the asterisk except when it heads the paragraph which describes it.

In some instances several names have been applied to the genotype. Such equivalency is indicated as often as possible. Some genotype designations are provisional, some are controversial, a few are uncertain, and in one or two cases we could not be sure that a genotype had ever been designated. Appropriate remarks on these situations are made where necessary.

Original spelling is given, but required corrections are made later if the species is described. Authorship of the species usually is not indicated unless it differs from that of the genus. It is given later, however, if the species is described, and we occasionally take the liberty of abbreviating multiple authorship in such cases (e.g. M and W = Meek and Worthen).

If generic and specific data can be condensed, we may add illustrative and descriptive data immediately after the genotype, but included within the parentheses, thereby eliminating repetition of the material in a later paragraph.

Generic Description. Descriptions of both genera and species are necessarily condensed, and include only a few of the characteristic or diagnostic features. It should be obvious on first thought that most of the descriptive matter was obtained from published sources. Because so many of our descriptions are merely rewording and recasting of published mate-

rial, it seems hardly fair to single out, by quotation marks, the occasional instances when we repeat small portions of an author's work verbatim.

Descriptions furnished by our colleagues are acknowledged and credited at the appropriate places throughout the book.

Age Indication. The stratigraphic range of the genus is indicated by the appropriate geologic period or epoch name or names, abbreviated and in boldface, and if necessary the division or divisions (e.g. **Camb.; Camb., Ord.; Camb.–Dev.; L. Camb.; L.** and **M. Camb.**). Abbreviations for time divisions are listed in the "Key" later in this chapter.

Geographic Distribution. If data on geographic distribution are given, they will follow the same order as discussed a little later under "Geographic Distribution of Species."

Order of Description of Species. Species are listed in stratigraphic order, the oldest first and the youngest last. For purposes of comparison, the genotype is sometimes considered first, even if it is not the oldest. Also, the general plan is sometimes modified for purposes of convenience. A number of contemporaneous species may be considered in the same paragraph if such treatment seems justified (e.g. Worms, Holothuroidea).

Species Name and Authorship. Each specific name appears in boldface; it follows the initial letter of its genus unless a subgenus intervenes, and it may have a paragraph of descriptive matter if its chief features are not apparent in the illustrations. An asterisk indicates a genotype. The specific name must agree in gender with that of the genus to which it is assigned, unless it is a noun or the name of a person; in the latter instance the name takes the genitive case and the gender of the individual. Every effort has been made to insure this agreement. In general the spelling of the original author has been followed.

The author or authors of the species are always indicated. If the original generic reference of the species has been changed, the author's name is inclosed in parentheses. If the present generic reference is uncertain, a question mark immediately follows the initial letter of the genus.

In a very few instances authorship is uncertain and an arbitrary decision had to be made. Justifiable objections to our choice may well be raised.

Designation of Illustrations. The plate and figure numbers for the species follow the author's name and are inclosed in parentheses (**197** — 1, 2) or brackets [**197** — 1, 2]. In general, all illustrations for a species appear on the same plate.

Age Designation of Species. Age or stratigraphic range of the species is designated in several ways; by geologic periods, or by subdivisions of successively shorter time down to individual formations. The designation used depends on the stratigraphic range of the genus to which the species is referred. Terminology, definition, and spelling of the divisional names follow those of the recent "Lexicon of Geologic Names of the United States (including Alaska)", by M. Grace Wilmarth (*USGS*, B 896: 1–2396, 1938).

In designating zones which bear the names of fossils, a generic name is not italicized (e.g. Lecanospira zone), but a generic-specific name is (e.g. *Exogyra costata* zone).

Formational names are often placed in parentheses after the abbreviated state or provincial name.

Geographic Distribution of Species. Distribution is stated in several ways. It may be the entire continent (N. America), a definite part of the continent (western N. America), some part of one of the countries (eastern Canada, central U. S. A.), a physiographic province (S. Appalachians, Upper Mississippi Valley, Wasatch Mts.), a geologic province (Cordilleran region), a specific area or a general area (Champlain region, Midcontinent region), a state or states, and a province or provinces. In citing distribution, we start with Greenland and proceed westward and southward as follows: Greenland, Arctic America, Newfoundland, eastern Canada, eastern U. S. A., Caribbean region, central Canada, central U. S. A., Alaska, western Canada, western U. S. A., and Mex. The abbreviations used for the several geographic divisions are listed in the "Key" later in this chapter.

ILLUSTRATIONS

Sources. The figures assembled on the plates were obtained from many sources and, as a consequence, several ways are used in the plate captions to credit these sources. The more important of the sources are:

(1) Federal and Dominion publications. The proper publication is credited, and is preceded by the initial letters of the organization (e.g. *USGS*, PP 125 = U. S. Geol. Surv., Prof. Paper 125; *CGS*, *COR*, d 3 = Geol. Surv. Canada, Canadian Organic Remains, decade 3).

(2) State and Provincial publications. The proper publication is credited to the survey of the state or province, with the abbreviated name preceding Geological Survey (e.g. *Ala G S*, B 2 = Alabama Geol. Surv., Bulletin 2; *Ont Dp Min*, An Rp 5 = Ontario Department of Mines, Annual Report 5).

(3) College and University publications. The proper publication is credited, being preceded by the name of the institution (e.g. *U Tex B* 3801 = University of Texas Bulletin 3801; *U Cal, Dp G*, B 25 = University of California, Department of Geology, Bulletin 25; *U Toronto Stud*, g s 7 = University of Toronto Studies, geological series 7).

(4) Serials. Figures obtained from this source are credited to the proper serial with titles abbreviated as indicated in the Key later in this chapter (e.g. *Ac N Sc Phila*, Pr 6 = Academy of Natural Sciences of Philadelphia, Proceedings 6; *JP* 5 = Journal of Paleontology, volume 5).

(5) Copyrighted textbooks. Several figures from "Invertebrate Paleontology," by Twenhofel and Shrock, are reproduced by the kind permission of

the McGraw-Hill Book Co., Inc. A number of figures appearing in the first edition of "North American Index Fossils" are used here. These are credited as [NAIF].

(6) New photographic prints of published figures, made from the original negatives, are credited to the individuals who furnished them.

(7) New photographs of specimens illustrated in published reports are credited to the persons who rephotographed the fossil. In some instances the place of publication of another figure of the specimen is cited (e.g. Walcott's trilobite figures; Resser's photographs).

(8) Original and unpublished photographs and drawings are credited to the persons who made them.

In sources 1 to 5 we generally have used the first figures published, but sometimes we have used later illustrations either because they portray the specimen better or because they show other material that is better preserved. Every effort has been made to procure the best possible illustrations.

In sources 6 to 8 full acknowledgments are made in the next few paragraphs and also at the appropriate places in the plate captions.

Acknowledgments. The plates in this book represent the work of numerous persons, to all of whom full credit is due.

Plates 1, 2, and 5 to 11 were prepared and numbered by Dr. J. A. Cushman and Miss Ruth Todd.

Plates 3 and 4 were prepared by Dr. Lloyd G. Henbest.

Plates 52 to 79 were prepared and numbered by Drs. R. C. Moore and L. R. Laudon.

Plates 93 and 94 were prepared and numbered by Drs. E. B. Branson and M. G. Mehl.

Plates 105 to 143 were prepared by Dr. G. Arthur Cooper, assisted by the junior author.

All other plates (12 to 51, 80 to 92, 95 to 104, and 144 to 303) were prepared by the junior author from published figures and from photographs and drawings furnished by numerous colleagues. Unless otherwise stated, Mrs. Kirk Stephenson placed the numbers on the plates.

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Plate Captions. Captions for the plates that were prepared by our colleagues, as stated in preceding paragraphs, were submitted to us by those authorities. All other plate captions were prepared by the junior author.

We have departed from the common practice of crediting illustrations to authors (e.g. *after Smith*) and instead, indicate the work from which the illustration was taken (e.g. *Md G S, L Dev* = Maryland Geological Survey, Lower Devonian) or credit it to the person who furnished the photograph or drawing. We believe the source-reference method is preferable because it allows the investigator to go directly to the proper work without first reading through a certain author's bibliography and then guessing which title appears the most likely.

It has been our intent, in preparing the captions, to locate and credit fully every illustration used and also to indicate the reduction or magnification of each figure. Any oversight will have been unintentional.

REFERENCES

General Statement. Investigators who use this book will find it necessary at times to consult the standard reference works for research in geology and paleontology. A fairly complete list of these references follows under several general headings.

General Bibliographies. The following works list all important paleontological literature on North America from 1785 to 1936 and are indispensable aids to any serious paleontological investigation.

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Bull. 746 (1923) (Nickles)
Part II, Index.
Bull. 747 (1924) "
1919–1928: Bibliography and Index.
Bull. 823 (1931) "
1929–1939: Bibliography and Index.
Bull. 937 (*In press*) (Thom)
1940–1941: Bibliography and Index.
Bull. 938 (1942) "

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Reference Lists Throughout the Text. An attempt has been made to assemble a brief list of references for each phylum, and for certain subdivisions of some of the phyla. These lists, it is hoped, include most of the more important works on the subject concerned to January 1, 1941, and should lead the serious investigator to the complete literature of the particular group in which he is interested.

If monographic or comprehensive works have been published on a certain division, its reference list is brief (e.g. Foraminifera). If, on the other hand, no comprehensive works have appeared, the list may contain a fairly large number of isolated and relatively small publications (e.g. Porifera). The reference list on the Crinoidea is unusually long and detailed because of the way it is used in the treatment of the subject and the citing of illustrations.

The authorship is indicated in one of the following ways:

If only one title is listed for an author, his name precedes the title. If more than one title is listed, then each successive title is preceded by a semicolon, indicating the same authorship as that of the first title in the series. If the author has a collaborator (or collaborators), the two (or more) names will appear before the first of their joint titles (e.g. **Ellis, B. F.,** and **Jones, E. B.**). Succeeding joint titles will be preceded by a semicolon.

Titles of papers are often considerably shortened by deletion of articles and other unessential words, but care has always been taken to preserve the mean-

ing of the title. Inserted editorial comments are set off by brackets [ ].

Place of publication is indicated by the appropriate abbreviations, which are listed in the Key later on. These abbreviations, while not always the conventional ones, should not be difficult to remember once the reader gets used to them.

Following the number of the volume, bulletin, etc., of the publication or periodical, and set off from it by a colon (:), are the pages, the plates (either indicated as pl 1–5, or simply il = illustrated), and finally the date of publication.

KEY TO ABBREVIATIONS AND SYMBOLS USED IN TEXT, REFERENCES, AND PLATE CAPTIONS

Many unconventional abbreviations and certain symbols have been used throughout this work in order to present maximum information in minimum space. Those which are restricted to a certain chapter, or to divisions thereof, are defined in the introduction to the chapter. Similarly, those restricted to captions for certain plates (e.g. Crinoidea and Brachiopoda) are defined at the head of the captions or in the introduction to the text material illustrated by the plates. An alphabetical list of the more common abbreviations and symbols follows:

AAAS	American Association for the Advancement of Science
AAPG	American Association of Petroleum Geologists
Abh	Abhandlungen
Abst	Abstract
Ac, Acad	Academy
Ac N S Phila	Academy of Natural Sciences of Philadelphia
Agr	Agriculture, agricultural
AJS (5) 23	American Journal of Science, 5th series, volume 23
Ak, Akad	Akademie
Ala.	Alabama
Alta.	Alberta
Am	America, American
Am Ac Sc	American Academy of Arts and Sciences
Am G, Am Geol	American Geologist
Am Mid Nat	American Midland Naturalist
Am Nat	American Naturalist
AMNH	American Museum of Natural History
Am Phil Soc	American Philosophical Society
An	Annals, annual, etc.
An Mag N H	Annals and Magazine of Natural History
An Rp	Annual Report
Anz	Anzeiger
App	Appendix
Arch	Archives
Ariz.	Arizona
Ark.	Arkansas
As, Assoc	Association
Auct, Auctt	Auctoris, um = of author (s)
B, Bol	Bulletin, Boletín, etc.
B Am Pal	Bulletins of American Paleontology
B. C.	British Columbia
Bd	Board, band
Beitr	Beiträge
Ber	Berichte
Bien	Biennial
Bos Soc N H	Boston Society of Natural History
Bot	Botany, botanical
Br	Branch
Brit	British
Bur	Bureau
Cal.	California
Camb.	Cambrian
Can.	Canada, Canadian
Can J	Canadian Journal
Can Nat	Canadian Naturalist and Geologist and Proceedings of the Natural History Society of Montreal
Can Rec N H	Canadian Record of Natural History and Geology
Can Rec Sc	Canadian Record of Science
Carnegie Inst.	Carnegie Institution of Washington
Centr	Centralblatt
CGS	Geological Survey of Canada, or Canada, Geological Survey
Cin Soc N H	Cincinnati Society of Natural History
CM, An	Carnegie Museum, Annals
cm	Centimeter(s)
Co(s)	County (-ies), Company
Col	Collection
Coll	College
Colo.	Colorado
Com	Commission
Con	Conservation
Cong	Congress, congressional
Conn.	Connecticut (without period when used in publication title)
Conserv	Conservation
Contr	Contribution
Contr Can Pal	Contributions to Canadian Paleontology
Contr Micropal	Contributions to the Micropaleontology of the Cambro-Silurian Rocks of Canada
COR, d 3 or dec 3	Canadian Organic Remains, decade 3
C R	Compte Rendu
Cret.	Cretaceous
CSNH	Cincinnati Society of Natural History
d, dec	Decade
D. C.	District of Columbia
Del.	Delaware

Deut	Deutsch, etc.
Dev.	Devonian
Doc	Document
Dp	Department
DUB, JSL	Denison University Bulletin, Journal of the Scientific Laboratories
E.	East, eastern
Ec Geol Helvetiae	Eclogae geologicae Helvetiae
Ed, ed	Edition, editor, etc.
Eng	Engineering
Eoc.	Eocene
Ex	Executive
Expl	Exploration (s)
Extr	Extract
Fasc	Fascicle
Field Mus N H	Field (Columbian) Museum of Natural History
Fig(s)	Figure (s)
Fla.	Florida
Fos	Fossil (s)
Fos Cat	Fossilium Catalogus, Animalia
Ft	Foot, Feet
Ga.	Georgia
G B or GB	Geological Bulletin
Geog	Geography, geographer, geographical, etc.
G, Geol	Geology, geologist, geological, etc.
Ges	Gesellschaft
G Mag	Geological Magazine
G S	Geological Survey, usually preceded by federal, state, dominion, or provincial name abbreviated
g s or gs	Geological series
g sc	Geological sciences
GSA	Geological Society of America
GSL, QJ	Geological Society of London, Quarterly Journal
H Ex Doc	House Executive Document
Hdbk	Handbook
H, Hist	History, histoire, etc.
il	Illustrated by figures of fossils
Ill.	Illinois
in.	Inch (es)
Ind.	Indiana
Ind T	Indian Territory
I, Inst	Institute, institution
Inst Geol Mex	Instituto Geológico de México
Int	International
Inv	Investigation (s)
Is, Isls	Island (s)
J	Journal
Jahrb, Jb	Jahrbuch
JG	Journal of Geology
Jour	Journal
JP	Journal of Paleontology
Jura.	Jurassic
K	Kaiserlich, königlich, etc.
Kan	Kansas
Ky.	Kentucky
L	London, Lower (L.)
Lond	London
La.	Louisiana
Linn Soc, J Zool	Linnean Society, Journal, Zoology, London
Lyc N H N Y	Lyceum of Natural History of New York; later N Y Ac Sc
M	Memoir, monograph, museum (depending on title of publication); Middle
m	Meter (s)
Mag	Magazine
Man (.)	Manitoba, manual
Mass.	Massachusetts
MCZ	Museum of Comparative Zoology (Harvard University)
Md.	Maryland
Me.	Maine
Med Grønland	Meddelelser om Grønland
Mem	Memoir (s), memorial
Mes Fos	Mesozoic Fossils [CGS]
Mex.	Mexico
Mich.	Michigan
Mil	Milwaukee
Min	Mine (s), mining, etc.
Miner	Mineral, mineralogy, mineralogist, mineralogical
Minn.	Minnesota
Mioc.	Miocene
Miss.	Mississippi, Mississippian (usually in boldface type)
Mitt	Mitteilungen
mm	Millimeter (s)
Mo.	Missouri, monthly (Mo)
Mon	Monograph
Mont.	Montana
Mus	Museum
Mus B	Museum Bulletin
N (.)	Natural, naturalist, new, north, northern (depending on title of publication or other use)
Nat	National, natural, naturalist
N. B.	New Brunswick
N. C.	North Carolina
N. Dak.	North Dakota
Neb.	Nebraska
Nev.	Nevada
Newf.	Newfoundland
N H	Natural History
NHS	Natural History Survey
N. J.	New Jersey
N. Mex.	New Mexico
non	Not
Nov	Novitates
nov	novum = new
N. S.	Nova Scotia
n s	New series
N Sc	Natural Science
NWT	Northwest Territories
N. Y.	New York

N Y St Cab	New York State Cabinet of Natural History
N Y St G	New York State Geologist
N Y St Mus	New York State Museum
Oc P	Occasional Papers
Okla.	Oklahoma
Olig.	Oligocene
Ont.	Ontario
Ord.	Ordovician
Ore.	Oregon
P	Page (s), Papers
p	Page (s)
Pa.	Pennsylvania
Pal	Paleontology, paleontologist, paleontological, etc.
Pal Abhand	Palaeontologische Abhandlungen
Pal Am or Americana	Palaeontographica Americana
Palaeontogr	Palaeontographica
Paleoc.	Paleocene
Pal Fos	Paleozoic Fossils [CGS]
Pal Zeit	Palaeontologische Zeitschrift
partim	In part
Penn.	Pennsylvanian
Perm.	Permian
Phila	Philadelphia
Pl, pl	Plate (s)
Pleist.	Pleistocene
Plioc.	Pliocene
PP	Professional Paper
Pr	Proceedings
Priv pub	Privately published, Private publication
Pt, (s)	Part (s)
Pub	Publication (s)
Q, Quart	Quarterly
QJ	Quarterly Journal
Que.	Quebec
R	Royal
Rev ed	Revised edition
Rp	Report (s)
R Soc Can	Royal Society of Canada
Rv	Review, revista, etc.
S (.)	Senate, south, southern
s	Series
Sask.	Saskatchewan
S. C.	South Carolina
Sc, sc	Science, scientific
Sch	School
sc s	Science or scientific series
S. Dak.	South Dakota
sec	Section
sess	Session
Sil.	Silurian
sl	Sensu lato (in a broad sense)
SMC	Smithsonian Miscellaneous Collections
Smith Contr Know	Smithsonian Contributions to Knowledge
Smith Inst	Smithsonian Institution
Soc	Society, Société, etc.
Soc Geol Belg	Société géologique de Belgique
Soc Geol France	Sociéte géologique de France
SP	Special Paper
sp.	Species (singular; used if species is uncertain or undetermined)
spp.	Species (plural)
S Pub, Sp Pub	Special Publication
S Rp, Sp Rp	Special Report
ss	Sensu stricto (in a restricted sense)
St.	Saint (masculine), State
Ste	Saint (feminine)
St L	Saint Louis
Stud	Studies
Sum Rp	Summary Report
Suppl	Supplement
Tenn.	Tennessee
Tert.	Tertiary
Tex.	Texas
Tr	Transactions
Trias.	Triassic
U, Univ	University; U. = Upper
U S, U. S. A.	United States, United States of America
U S Geog S W 100th Mer	United States Geographical Survey West of the One Hundredth Meridian (Wheeler)
USG Expl 40th Par	United States Geological Exploration of the 40th Parallel (King)
USGS	United States Geological Survey
USGS Ter	United States Geological Survey of the Territories (Hayden)
US Pacific RR Expl	United States Pacific Railroad Explorations
USNM	United States National Museum
U. S. S. R.	Union of Socialist Soviet Republics
V, v	Volume (s)
Va.	Virginia
var	Variety
Verh	Verhandlungen
Victoria Mem Mus	Victoria Memorial Museum
Vol, vol	Volume (s)
Vt.	Vermont
W	West, western
Wag Free Inst Sc	Wagner Free Institute of Science
Wash.	Washington
WFIS	Wagner Free Institute of Science
W. I.	West Indies
Wis.	Wisconsin
W. Va.	West Virginia
Wyo.	Wyoming
Zool	Zoology, zoologist, zoological
Zeit, Zeitschr, Zs	Zeitschrift
Ztg	Zeitung

CHAPTER II

PHYLUM PROTOZOA

The Protozoa include a vast group of typically microscopic, one-celled, aquatic animals composed of undifferentiated jellylike protoplasm with or without hard parts. The phylum, which is abundantly represented in existing fresh-water and marine bodies, has left a long geologic record, though fossils are uncommon before the Mississippian.

Protozoa are subdivided into four classes: **Mastigophora, Sarcodina, Sporozoa,** and **Infusoria.** Only the first two have a fossil record of any importance.

CLASS MASTIGOPHORA

Flagellate protozoans with cell wall fixed and shape permanent; usually lacking hard parts but with a siliceous skeleton in a few groups.

Order Silicoflagellata.[1,2] Microscopic protozoans with siliceous skeletons of spicular or discoidal form **U. Cret.–Recent** (U. S. A.; Mexico).

Hanna (1928) has recently pointed out that silicoflagellates are ideal and valuable horizon markers because (1) they usually are common if they occur at all, (2) the number of species in any formation is exceedingly limited, (3) species have very short stratigraphic range, (4) being pelagic, they have wide geographic distribution, and (5) species are so distinct that they can be identified readily.

CORBISEMA Hanna 1928

(**C. geometrica*). A triangular, hyaline, central cell joined to an outer, roundly triangular border with three straight bars of silica. **Cret.**

***C. geometrica** Hanna (**14**—6). **U. Cret.:** Cal. (Moreno).

LYRAMULA Hanna 1928

(**L. furcula*). A simple bar of silica, either smooth or more or less scalariform, bent into a U or Y shape. **Cret.**

***L. furcula** Hanna (**14**—7, 8). **U. Cret.:** Cal. (Moreno).

VALLACERTA Hanna 1928

(**V. hortoni*). A convex, sculptured, pentagonal disk with a heavy siliceous spine at each corner. **Cret.**

***V. hortoni** Hanna (**14**—17). **U. Cret.:** Cal. (Moreno).

MESOCENA Ehrenberg 1843

(**M. elliptica*). A simple ring of varying shape with two or more short spines on periphery. **Tert.**

***M. elliptica** Ehrenberg (**14**—18). **Mioc.:** Cal.

NAVICULOPSIS Frenguelli 1940

(**N. biapiculata* Lemmermann). A long oval with a bar across the center and a spine at each end. **Tert.**

***N. biapiculata** Lemmermann (**14**—9, 10). **U. Mioc.:** Cal. (Monterey).

DICTYOCHA Ehrenberg 1837

(**D. fibula*). A quadrangular figure with a spine at each angle and central bars rising from middle of each side to meet in a rounded apex. **Tert.**

***D. fibula** Ehrenberg (**14**—15). **U. Mioc.:** Cal. (Monterey).

EBRIA Boigert 1891

(**Dictyocha fornix* Möbius). An irregular ring with three bars meeting at an apex and the same below but rotated about 60°. **Tert.**

E. antiqua Schulz (**14**—16). **U. Mioc.:** Cal. (Monterey).

DISTEPHANUS Haeckel 1862

(**Dictyocha specula* Ehrenberg). An outer hexagonal figure with lone spines at the angles and an inner raised figure, connected by sloping bars. **Tert.**

D. ornamentatus Ehrenberg (**14**—19). **U. Mioc.:** Cal. (Monterey).

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[1] Grateful acknowledgment is due Dr. G. D. Hanna for illustrative and text material.

[2] **Deflandre, G.,** Les Silicoflagelles des terres fossiles à Diatomees: *Soc Franc de Micros*, B 1: 10–20, 1932; Sur la systématique des Silicoflagelles: *Soc Bot de France*, B 79: 494–506, 1932. **Frenguelli, J.,** Considéraciones sobre los Silicoflagelados fósiles: *Rev Mus La plata* (ns), sec Paleo, T 2: 37–112, 1940. **Gemeinhardt, K.,** Silicoflagellatae [in **Dr. L. Rabenhorst's** Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz], V 10, pt 2: 1–88, 1930. **Hanna, G. D.,** Silicoflagellata from the Cretaceous of California, *JP* 1: 259–264, 1928; The Monterey shale of California at its type locality with a summary of its fauna and flora: *AAPG*, B 12: 969–983, 1928; Diatoms and silicoflagellates of the Kreyenhagen shale: *Cal St Min*, Rp 27: 187–201, 1931. **Lemmermann, E.,** Silicoflagellata: *Ber Deutsch Bot Ges* 19: 247–271, 1901. **Schulz, P.,** Beiträge zur Kenntnis fossiler und rezenter Silicoflagellaten: *Bot Archiv* 21: 225–292, 1928. **Wetzel, O.,** Die in organischer substanz erhaltenen Mikrofossilien des baltischen Kreidefeuersteins mit einem sediment-petrographischen und stratigraphischen Anhang [Microfossils preserved as organic substance in Baltic Cretaceous flints, with a sediment-petrographic and stratigraphic appendix]: *Paleontogr* 77: 141–186; 78A: 1–110, 1933 [Reviewed by **M. I. Goldman** in *JP* 8: 482–483, 1934]. **Zanon, V.,** Silicoflagellate fossili italiene: *Act P Ac Sc Nov Lunc* 86: 3–44, 1934.

COCCOLITHS and RHABDOLITHS

Small calcareous disks (*coccoliths* [**14**—12, 13]) and spicular bodies (*rhabdoliths* [**14**—19]), which occur abundantly with Foraminifera in modern marine-bottom deposits, have been referred by some investigators to the Mastigophora; other investigators, however, believe that these bodies are of algal origin. Similar bodies have been reported as fossils from rocks as old as the Cretaceous.[1]

CLASS SARCODINA

Marine or fresh-water protozoans which alternately protrude and retract fingerlike extensions (pseudopodia) of the body. Most of the orders have either no known fossil representation or a very meager one. The Radiolaria have a small but interesting representation. The Foraminifera, however, have a large and very useful fossil record which extends back as far as the Cambrian and is especially important since the beginning of the Mississippian.

Order Foraminifera.[2,3] Foraminifera are almost entirely marine animals, though a few do live in brackish or fresh waters. Except for a few of the simplest types, the organism secretes a protective and supporting skeleton which is usually designate dthe *test*. These tests occur as fossils from the Cambrian to the Recent and are abundant in rocks younger than Devonian. In shallow waters today their great numbers may form obstructing shoals. Most species are bottom dwellers (vagrant and sessile benthos), crawling very slowly on the ocean bottom materials (muds and oozes) or attached to various objects on the ocean floor. Only perhaps two dozen species are pelagic, floating at or near the surface of the ocean, and most of these are restricted to the two families Globigerinidae and Globorotaliidae.

Fossil tests range in size from microscopic up to several inches in diameter — large forms are especially characteristic of the Eocene and Oligocene — but only one living species (in the Indo-Pacific region) reaches such a large size. One of the most primitive tests is composed of chitin; another is composed of such foreign materials as sand grains, sponge spicules, or mica flakes, more or less firmly cemented together by a secretion which may be chitinous, ferruginous, siliceous, or calcareous (these agglutinated tests are usually designated as *arenaceous*); in a few groups completely siliceous tests may develop, though these are uncommon; nearly all foraminifers secrete a calcareous test which is usually perforate, so that the pseudopodia may be extruded from all parts of the body instead of only through the main opening or *aperture*. The main aperture varies greatly in outline from round to radiate, in different species; and in many forms a tooth of some sort is developed in the aperture.

Two forms of a species are usually found together, one small but with a large initial chamber (*proloculum*), the other of larger size but starting with a much smaller proloculum. The former is designated the *megalospheric* form, the latter the *microspheric*. The two variations are due to different modes of reproduction, because Foraminifera are characterized by an alternation of asexual and sexual generations. In the development of the asexual generation, each of the many nuclei within the microspheric test gathers a mass of the mother protoplasm about itself and leaves the test, whereupon it secretes the large proloculum of a new test, the first chamber of the megalospheric form. When this form attains maturity, the single nucleus breaks up into a great many, each of which, again taking some of the mother protoplasm, subdivides into minute flagellated *zoospores*, which then leave the old test. The individual resulting from the chance union of two zoospores secretes the small proloculum of the microspheric test. It is obvious, therefore, that megalospheric forms of a species will be much more abundant than microspheric. The empty tests, deserted during reproduction, must form a large proportion of foraminiferal deposits.

The architecture of the test is extremely variable, ranging from a single, simple chamber to a complicated, variously coiled, multi-chambered structure. A single-chambered test is described as *unilocular*; one with many chambers, *multilocular*. Chambers may be arranged along a single axis, in which case the test is described as *uniserial* or *rectilinear*; they may be arranged in two rows, one on each side of the axis, hence *biserial*; or three rows in *triserial* forms, etc. In other forms they may be arranged along a spiral line in a plane, in which case they are designated *planispiral*, or they may follow a conical helix to form a *trochoid* test. *Evolute* tests have all chambers visible; *involute* ones show only the last chamber, or the last whorl of chambers.

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[1] **Dawson, G. M.**, Foraminifera, Coccoliths, and Rhabdoliths from Cretaceous of Manitoba: *Can Nat* 7: 252–257, il, 1874. **Woodward, A.**, and **Thomas, B. W.**, Microscopical fauna of Cretaceous in Minnesota: *Minn G S* 3 (1): 23–54, il, 1895.

[2] The descriptions and illustrations of the Foraminifera are almost entirely the work of Drs. Joseph A. Cushman, W. Storrs Cole, and Lloyd G. Henbest, to whom the appropriate sections are credited. The authors hereby make grateful acknowledgment for these contributions.

[3] **Cushman, J. A.**, Foraminifera, their classification and economic use, 3rd ed, revised and enlarged with An Illustrated Key to the Genera: *Harvard Univ Press* (Cambridge, Mass.), p 1–535, pl 1–79, 1940 [reviewed by **H. J. Plummer** in *Am Mid Nat* 24: 261–270, 1940; by **H. G. Schenck** in *JP* 14: 603–605, 1940; and by **B. N. Cooper** in *AAPG*, B 24: 1498, 1940]. **Ellis, B. F.**, and **Messina, A. R.**, A Catalogue of the Foraminifera: *AMNH*, Sp Pub: 1–30,000, il, 1942 [reviewed by **B. F. Howell** in *Science* 92: 606–607, 1940, and by **C. Croneis** in *JG* 50: 560–562, 1942]. **Galloway, J. J.**, A Manual of Foraminifera, The Principia Press (Bloomington, Ind.), p 1–483, pl 1–42, 1933. **Thalman, H. E.**, Bibliography and Index to new genera, species, and varieties of Foraminifera for the years 1937 and 1938: *JP* 15: 629–690, 1941; [Same] for year 1939; *JP* 16: 489–520, 1942.

Authors to whom figures are credited in the plate captions are listed in the bibliographies of the above-cited works.

Coiling may be about a hollow cone, in which case the test has an *umbilicus*; and this may be filled with a *plug* of shell material. The line of junction between adjacent chambers is the *suture*, and this may be depressed, even with the surface, or elevated above it. If it is much thickened it is described as *limbate*. The side of the test bearing the aperture is usually *ventral*, the opposite *dorsal*. The *aperture face* is the curved portion of the chamber wall rising above the aperture. Chambers may be divided into *chamberlets* by *septa* and similar partitions, and the resulting complex structure is described as *labyrinthic* or *labyrinthine* if the chamberlets are partly filled with secondary shell material.

A few suggestions may be introduced here for preparing foraminiferal material for study. If the foraminifers are in loose sediment containing mud and fine sand, they should be washed in brass nested sieves with 40, 80, and 200 meshes to the inch. The material is placed in the coarsest sieve and a fine spray of water is played upon it as the sieves are shaken.

After this washing, the foraminifers may be sorted by "spinning" or "panning," as in panning gold; the lighter shells will come to the margin of the watch glass or other shallow dish used as the water is given a circular motion. Another method is to dry the material after washing, then heat it slightly and throw it into a dish of cold water; the tests, being filled with air, will float upon the surface and may be poured off. In still another method, heavy liquids such as tetrabromethane or carbon tetrachloride have been used to concentrate the tests, which will float on the liquid. The method used will usually depend upon the character of the sediments and of the Foraminifera.

Many shales may be suspended as a mud by being soaked overnight in water, and others may be "dissolved" by boiling in alkaline solutions like soda or potash. Harder material may be fractured and good specimens obtained from the cracked surfaces and loose powder. With very hard compact material, such as limestones, weathered surfaces should give some good exteriors; otherwise one must resort to sectioning.

A binocular microscope with a large field is almost a necessity in studying Foraminifera, as well as other microscopic fossils. For picking out individual specimens a moistened brush serves best. One made of red sable bristles is better than a "camel's hair" since, being more elastic, it will last longer. If it is left moistened with the tip drawn to a point, it may be used for a long time.

If Foraminifera are used for correlation, it should be borne in mind that erosion of an older formation may have furnished the specimens being studied, in which case the specimens have been redeposited and do not, therefore, have time significance with respect to the containing rock. This is especially true of neritic or shoreward deposits. The smaller the fossil, the more likely is this redeposition.

DESCRIPTIONS OF GENERA AND SPECIES

PREPARED BY JOSEPH A. CUSHMAN[1]

PROTEONINA Williamson 1858

(**P. fusiformis*). Test free, a fusiform or flask-shaped undivided chamber; wall a thin chitin layer on which are cemented sand grains, mica flakes, other tests, etc.; aperture usually circular, often with a slight neck, which may become elongate. **Carb.–Recent.**

P. difflugiformis Brady (1—1). **U. Cret.–Mioc.:** U. S. A.

URNULINA Gruber 1884

(**U. difflugiaeformis*). Test free, obovate, initial end pointed, apertural end broad; wall thin, arenaceous; aperture terminal, large, and rounded. **Mioc.–Recent.**

U. compressa Cushman (1—2). **Mioc.:** Fla.

HYPERAMMINOIDES Cushman and Waters 1928

(**Hyperamminella elegans*). Test free, with a proloculum and elongate, tapering second chamber, compressed or rounded, constricted on the exterior; wall finely arenaceous with siliceous cement; aperture terminal, circular or elliptical, often with slight lip. **Penn.**

H. elegans (C and W) (**1**—3, 4). **Penn.:** Tex.

EARLANDIA Plummer 1930

(**E. perparva*). Test free, very elongate, composed of a globular or subglobular proloculum and an elongate, nonseptate second chamber; wall of minute, crystalline, calcareous granules bound by a calcareous cement, imperforate, smoothly finished; aperture a broad, circular opening at end of tube. **Penn.**

***E. perparva** Plummer (**1**—5). **Penn.:** Tex.

REOPHAX Montfort 1808

(**R. scorpiurus*). Test free, elongate, composed of a series of undivided chambers, ranging from overlapping to remotely separated, in a straight or curved linear series; wall typical with a chitinous base and an outer wall of agglutinated material; firmly cemented sand grains, mica flakes, sponge spicules, or other foraminifers; aperture simple, terminal, some with a slight neck. **Camb.–Recent.**

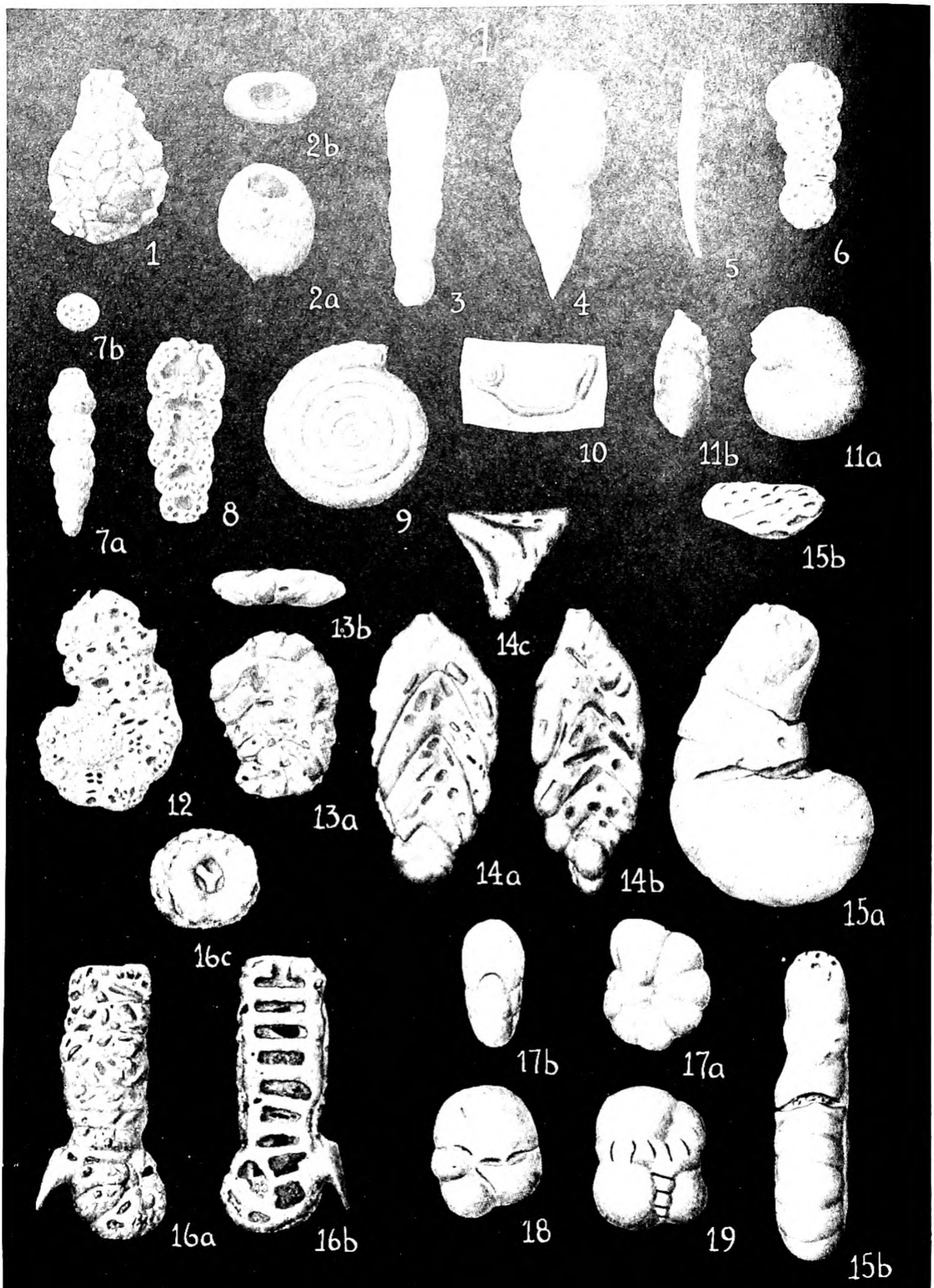
R. texana Cushman and Waters (1—6). **U. Cret.:** Alta.; Tex.

HAPLOSTICHE Reuss 1861

(**Dentalina foedissima*). Test free, cylindrical or tapering, composed of a linear series of chambers, interior labyrinthic; wall thick, coarsely arenaceous; aperture in the young simple, later of several pores or dendritic, terminal, occasionally with a short neck. **Jura.–Recent.**

H. texana (Conrad) (**1**—7, 8). **L. Cret.:** Tex.

[1] Grateful acknowledgment is due Miss Ruth Todd for her assistance in the preparation of this material.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AMMODISCUS Reuss 1861

(**Operculina incerta* Orbigny). Test free. planispiral, with a proloculum and long, tubular, undivided second chamber; wall arenaceous, varying greatly in the size of particles and relative amount of cement; aperture formed by open end of tubular chamber. **Camb.?, Sil.–Recent.**

A. semiconstrictus regularis Waters (1—9). **Penn.:** Okla., Tex.

TOLYPAMMINA Rhumbler 1895

(**Hyperammina vagans* Brady). Test attached, with proloculum and long, tubular, undivided second chamber, earliest portion sometimes coiled, later irregular; wall arenaceous with much cement; aperture at end of tube. **Penn.–Recent.**

T. delicatula Cushman and Waters (1—10). **Penn.:** Tex.

HAPLOPHRAGMOIDES Cushman 1910

(**Noniorina canariensis* Orbigny). Test free, planispiral, of several coils, usually not completely involute; chambers simple; wall single, arenaceous or with sponge spicules, firmly cemented, amount of cement varying greatly in different species; aperture simple, at base of apertural face of chamber. **Carb.–Recent.**

H. glabra Cushman and Waters (1—11). **U. Cret.:** Tex.; western Canada.

AMMOBACULITES Cushman 1910

(**Spirolina agglutinans* Orbigny). Test free, early chambers close coiled, later ones typically in a linear series, simple; wall arenaceous, with a chitinous lining; aperture in early stages at base of apertural face, in the adult rounded, terminal, and simple. **Carb.–Recent.**

A. taylorensis Cushman and Waters (1—12). **U. Cret.:** Tex.

FLABELLAMMINA Cushman 1928

(**F. alexanderi*). Test free, much compressed, early stages close coiled, later developing low broad chambers in an inverted V-shape; microspheric form broad and fan-shaped, megalospheric form more elongate and narrow; wall coarsely arenaceous, with much fine material and cement; aperture in the adult terminal, elliptical. **Cret.**

F. saratogaensis Cushman (1—13). **U. Cret.:** Ark., Tex.

FRANKEINA Cushman and Alexander 1929

(**F. goodlandensis*). Test free, early stages planispiral, compressed, later uncoiling and becoming triangular in section; chambers simple; wall coarsely arenaceous but firmly cemented; aperture at base of apertural face in early coiled portion, later terminal, simple. **Jura.?, Cret.**

***F. goodlandensis** C and A (1—14). **L. Cret.:** Tex.

HAPLOPHRAGMIUM Reuss 1860

(**Spirolina aequalis* Roemer). Test free, early chambers close coiled, later ones in a rectilinear series, simple; wall arenaceous with a chitinous lining; aperture in young at base of apertural face, becoming terminal and multiple in uncoiled portion. **Cret.–Recent.**

H. taylorensis Cushman and Waters (1—16). **U. Cret.:** Tex.

ENDOTHYRA Phillips 1846

(**E. bowmani*). Test free, close coiled, often completely involute, early chambers with the plane of coiling changing; chambers numerous, distinct, simple; wall arenaceous, usually with a large amount of cement, in some places appearing double, exterior smoothly finished; aperture simple, typically narrow, at base of apertural face. **Dev.?, Miss.–Trias.**

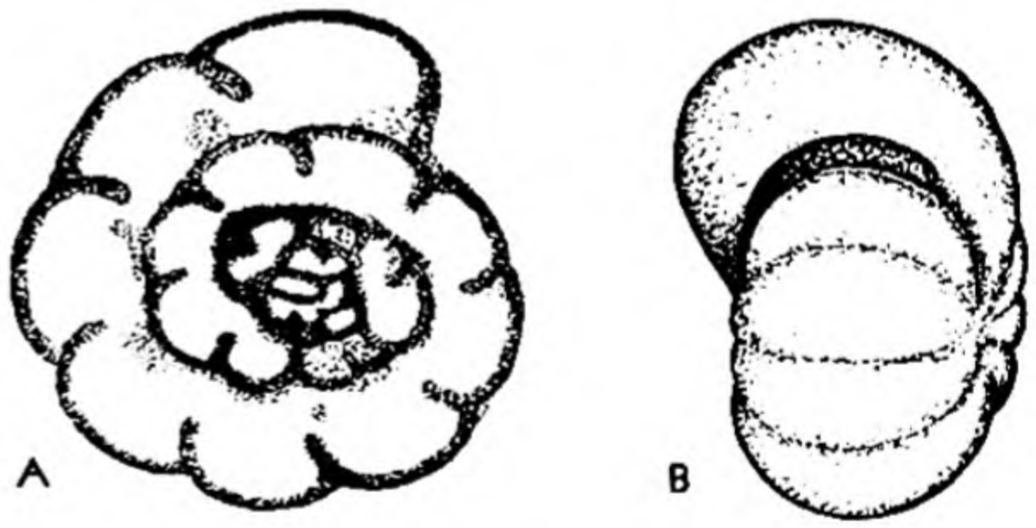


FIG. 1. Equatorial section and front view of *Endothyra baileyi* (Hall) (x30). (Original drawing by Lloyd G. Henbest.)

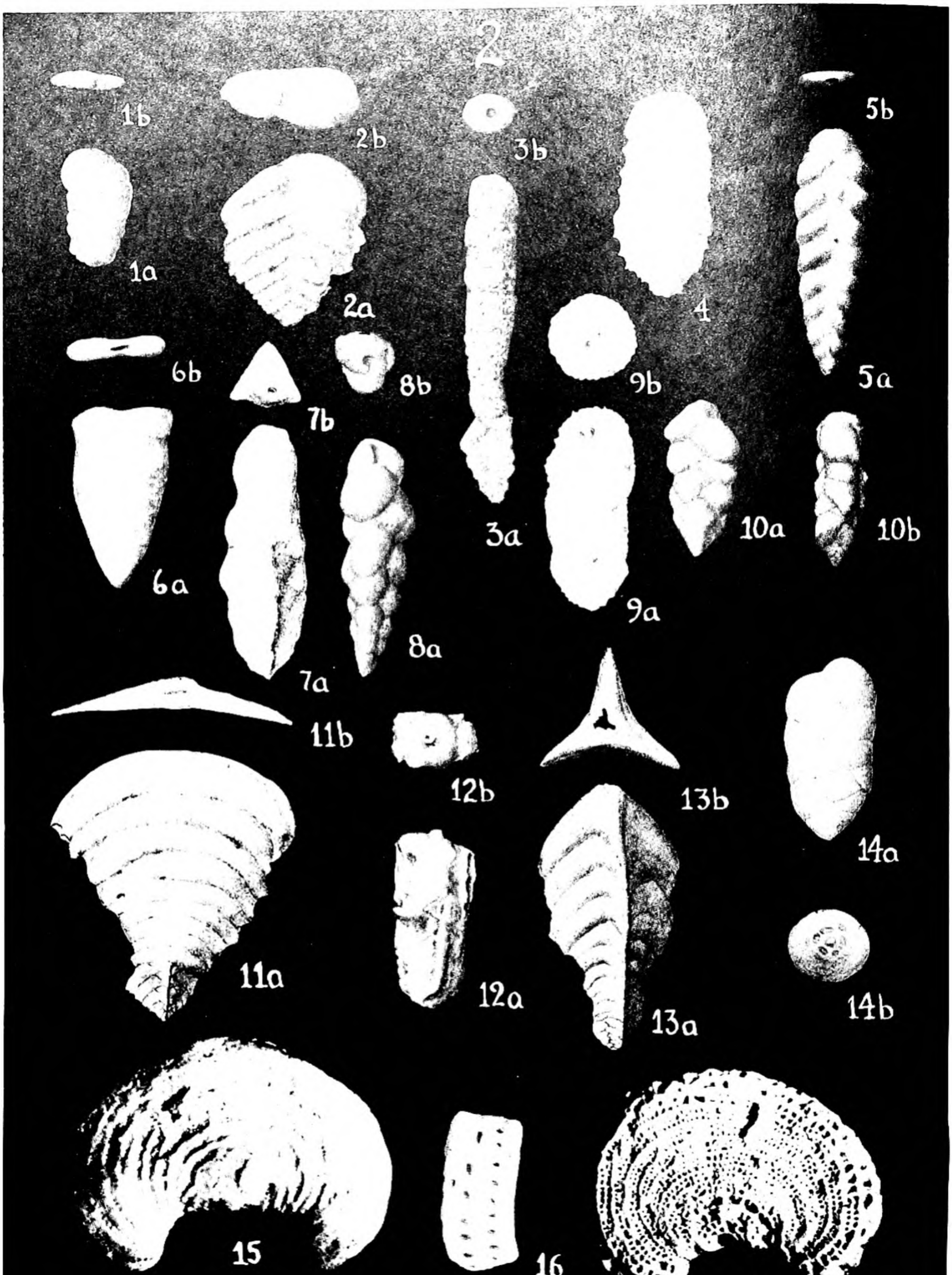
E. baileyi (Hall) (Text Fig. 1). Rather large,

In the captions for plates 1–14, figures are usually credited to authors. These authors are listed in Cushman's "Foraminifera . . .," p 335–394, 1940.

PLATE 1

[Figures are after Cushman unless other authors are indicated in brackets; C and W = Cushman and Waters.]

1. Proteonina difflugiformis (x50). **2. Urnulina compressa** (x60). 2a, 2b: side and apertural views. **3, 4. Hyperamminoides elegans** (x35). 3: megalospheric; 4: microspheric. **5. Earlandia perparva** (x25) [U Tex B 3019]. **6. Reophax texana** (x15). **7, 8. Haplostiche texana** (x6) [U Tex B 3101]. 7a, 7b: side and apertural views; 8: longitudinal section. **9. Ammodiscus semiconstrictus** var. **regularis** (x90) [C and W]. **10. Tolypammina delicatula** (x50) [C and W]. **11. Haplophragmoides glabra** (x70). 11a, 11b: side and apertural views. **12. Ammobaculites taylorensis** (x25). **13. Flabellammina saratogaensis** (x18). 13a, 13b: side and apertural views. **14. Frankeina goodlandensis** (x50) [Cushman and Alexander]. 14a, 14b, 14c: side and apertural views. **15. Lituola taylorensis** (x10) [C and W]. 15a, 15b, 15c: side, edge, and apertural views. **16. Haplophragmium taylorensis** (x25) [C and W]. 16a, 16c: side and apertural views; 16b: section. **17. Endothyra media** (x40) [C and W]. 17a, 17b: side and apertural views. **18, 19. Glyphostomella trilocullna** (x35) [C and W]. 18: young stage; 19: adult.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asymmetrically coiled, with axis the shortest dimension; equatorial diameter 0.7 to 1.2 mm, average 0.9 mm; seven to ten chambers in last volution; three to four volutions; chambers subspherical, with but little subordination to architecture of shell; sutures deep and but little distinction between septal and spiral walls; growth direction highly varied, wanders greatly in juvenarium, becomes trochoid or nearly planispiral in adult stage; commonly more or less involute; shell granular, calcareous, probably agglutinate and probably porous; outer rind or tectum locally developed; aperture crescentic slit at base of antetheca and commonly guarded by a dam or moraine of porous, secondary shell material. This and the similar species *E. bowmani* of England and Europe are widely distributed and locally are important rock-forming shells. **M. Miss.:** Ind. (Salem), Ill., Midcontinent region. (The description and illustrations of this species were contributed by Lloyd G. Henbest.)

E. media Waters (1—17). **Penn.:** Tex.

GLYPHOSTOMELLA Cushman and Waters 1928

(**Ammochilostoma? triloculina*). Test free, involute, early chambers not bilaterally symmetrical, later ones nearly so; wall finely arenaceous, with a large proportion of cement; apertures in early stages parallel to margin of chamber and suture, later developing at right angles to base of chamber, several to a chamber and occasionally irregular ones in apertural face; apertures connecting with interior by a funnel-shaped structure. **Penn.**

***G. triloculina** (C and W) (1—18, 19). **Penn.:** Tex.

LITUOLA Lamarck 1804

(**L. nautiloidea*). Test in the early stages planispiral, later portion typically uncoiled and straight, interior labyrinthic; wall arenaceous with much cement; aperture in early stages at base of apertural face, single, later becoming multiple and in the terminal face. **Carb.–Recent.**

L. taylorensis Cushman and Waters (1—15). **U. Cret.:** Tex.

SPIROPLECTAMMINA Cushman 1927

(**Textularia agglutinans biformis* Parker and Jones). Test free, early chambers planispiral in both microspheric and megalospheric forms, and forming a considerable portion of test, later chambers biserial; wall arenaceous, amount of cement variable; aperture a low opening at base of inner margin. **Penn.–Recent.**

S. castensis Cushman and Waters (2—1). **Penn.:** Tex.

TEXTULARIA Defrance 1824

(**T. sagittula*). Test free, elongate, tapering, typically compressed with the zigzag line between chambers on middle of flattened side, early chambers in microspheric form usually planispirally coiled, later biserial, chambers simple, not labyrinthic; wall arenaceous, cement of various sorts, the relative amount variable; aperture typically an arched slit at inner margin of chamber, occasionally in apertural face. **Camb.–Recent.**

T. ripleyensis Berry (2—2). **U. Cret.:** Tenn., Ala., Tex.

BIGENERINA Orbigny 1826

(**B. nodosaria*). Test free, early chambers biserial, later ones uniserial, in a rectilinear series, not labyrinthic; wall arenaceous, relative amount of cement varying greatly; aperture in biserial stage as in *Textularia*, in adult uniserial stage terminal, simple. **Penn.–Recent.**

B. wintoni Cushman and Alexander (2—3). **L. Cret.:** Tex.

VULVULINA Orbigny 1826

(**V. capreolus*). Test free, much compressed throughout, early stages biserial, or planispirally coiled in the microspheric form, later chambers uniserial, simple; wall arenaceous, with a large proportion of cement; aperture elongate, elliptical, simple, terminal. **Eoc.–Recent.**

V. advena Cushman (2—4). **U. Eoc.:** Ala.; Cuba; Mexico.

SPANDELINA Cushman and Waters 1928

(**S. excavata*). Test uniserial, chambers in a generally rectilinear series, the earlier ones at least compressed, especially in the microspheric form; wall calcareous, finely arenaceous, with a thin coating; aperture simple, terminal, elliptical or rounded. **Penn.?, Perm.**

***S. excavata** C and W (2—5). **Perm.:** Tex.

GEINITZINA Spandel 1901

(**Textularia cuneiformis* Jones (not Orbigny)). Test free, much compressed, especially along median line, in microspheric form showing a trace of biserial

PLATE 2

[Figures are after Cushman unless other authorship is indicated in brackets; C and A = Cushman and Alexander; C and W = Cushman and Waters.]

1. Spiroplectammina castensis (x50) [C and W]. 1a, 1b: side and apertural views. **2. Textularia ripleyensis** (x65). 2a, 2b: front and apertural views. **3. Bigenerina wintoni** (x35) [C and W]. 3a, 3b: side and apertural views. **4. Vulvulina advena** (x30). **5. Spandelina excavata** (x50) [C and W]. 5a, 5b: side and apertural views. **6. Geinitzina ciscoensis** (x50) [C and W]. 6a, 6b: side and apertural views. **7. Tritaxia plummerae** (x28). 7a, 7b: side and apertural views. **8. Verneuilina schizea** (x50) [C and A]. 8a, 8b: side and apertural views. **9. Valvulina ocalana** (x46). 9a, 9b: side and apertural views. **10. Gaudryina triangularis** (x30). 10a, 10b: side and edge views. **11. Clavulinoides compressa** (x35). 11a, 11b: side and apertural views. **12. Heterostomella foveolata** (x60). 12a, 12b: side and apertural views. **13. Clavulinoides insignis** (x20). 13a, 13b: side and apertural views. **14. Dorothia bulletta** (x42). 14a, 14b: front and basal views. **15–17. Gunteria floridana** (x40) [Cushman and Ponton]. 15: exterior; 16: eroded specimen showing interior structure; 17: apertural view of young specimen.

ancestry; wall finely arenaceous, with much cement and a thin outer layer when well preserved; aperture terminal, elliptical. **Penn., Perm.**

G. ciscoensis Cushman and Waters (2—6). **Penn.:** Tex.

VERNEUILINA Orbigny 1840

(**V. tricarinata*). Test triserial throughout, usually triangular in transverse section, but earlier species usually with angles rounded; chambers distinct, three making up each whorl, usually increasing in size toward apertural end; sutures usually distinct, either depressed or in some species raised and somewhat limbate; wall arenaceous, variable in coarseness and relative amount of cement; aperture textularian, usually a low opening, occasionally somewhat arched, at base of inner margin of last-formed chamber. **Jura.–Recent.**

V. schizea Cushman and Alexander (2—8). **L. Cret.:** Tex.

TRITAXIA Reuss 1860

(**Textularia tricarinata*). Test triserial, triangular in transverse section, the angles acute or somewhat rounded; chambers usually distinct but not inflated, three making up each whorl, but the last one or more chambers in the adult terminal, usually somewhat contracted; sutures usually distinct and slightly depressed; wall arenaceous, usually of fine particles, with much cement, the exterior usually smoothly finished; aperture in early stages textularian, a low opening at inner margin of last-formed chamber, in adult becoming terminal and usually rounded. **Cret.**

T. plummerae Cushman (2—7). **L. Cret.:** Tex.

GAUDRYINA Orbigny 1839

(**G. rugosa*). Test with chambers triserial, adult biserial, early portion typically triangular with distinct angles, but in some species chambers are rounded, and angles obtuse or broadly rounded; adult portion with biserial chambers of various shapes, either rounded or more or less quadrate, or with one series having periphery truncate and opposite series with a distinct angle; chambers usually distinct, the early ones sometimes obscure; sutures usually distinct except in early portion, typically depressed, very rarely limbate; wall arenaceous throughout, either coarsely arenaceous with very little cement or composed of fine fragments and much cement, the surface ranging from very rough to smooth; aperture in early stages at inner margin of last-formed chamber, usually with a distinct re-entrant, in some species tending to become terminal in the final chamber. **Jura.–Recent.**

G. triangularis Cushman (2—10). **Plioc.:** Cal.

CLAVULINOIDES Cushman 1936

(**Clavulina trilatera*). Test elongate, in most species triangular, in some the latest chambers rounded; earliest portion triserial, triangular, frequently with an early biserial stage following triserial portion, in which one of the three sides is narrower than the other two; adult uniserial; chambers in many species distinct, in a few somewhat obscure, particularly in early portion; wall coarsely to finely arenaceous, amount of cement variable, surface either smooth or somewhat roughly finished; aperture in adult becoming terminal, rounded, or with radiating portions toward angles of test, and without a distinct tooth. **U. Cret.–Recent.**

C. compressa (Cushman) (2—11). **U. Cret.:** Tenn., Ark., Tex.

C. insignis (Plummer) (2—13). **U. Cret.:** Miss., Ark., Tex.

HETEROSTOMELLA Reuss 1865

(**Sagrina rugosa* Orbigny). Test in early stages triserial, triangular in section, later biserial with one of angles of test dividing and forming a somewhat quadrangular test, the ridges formed by angles becoming fistulose, and occasional supplementary ridges added to the four primary ones; wall arenaceous, usually with much cement; aperture in young as in *Gaudyrina*, later with a terminal aperture, frequently with a slight neck. **U. Cret.**

H. foveolata Marsson (2—12). **U. Cret.:** Ark.

VALVULINA Orbigny 1826

(**V. triangularis*). Test free or attached, spiral, conical, triserial, usually umbilicate, typically with three chambers throughout, but the megalospheric form with the adult having more than three chambers to a whorl; wall arenaceous, of coarse or fine material, surface very rough to smooth; aperture with a distinct, valvular tooth. **Jura.–Recent.**

V. ocalana Cushman (2—9). **U. Eoc.:** Fla.

DOROTHIA Plummer 1931

(**Gaudryina bulletta* Carsey). Test a trochoid spire, in early stage in microspheric form with five or six chambers in a whorl, rapidly reducing the number to four, then three, and in the adult with two in each whorl; wall arenaceous, becoming largely calcareous in some living forms; aperture narrow, at base of inner margin. **Cret.–Recent.**

***D. bulletta** (Carsey) (2—14). **U. Cret.:** Ala., Miss., Ark., Tex.

GUNTERIA Cushman and Ponton 1933

(**G. floridana*). Test trochoid in young, but in adult becoming much compressed, the ends of chambers becoming curved back and a saddle-shaped test resulting, tending toward an annular growth; apertures in a narrow band representing central shield. **M. Eoc.**

***G. floridana** C and P (2—15–17). **M. Eoc.:** Fla.; Cuba.

FUSULINIDAE[1,2]

PREPARED BY LLOYD G. HENBEST

Large, length about 0.5 to 30 mm, rarely 50 or 60 mm; typically fusiform, cylindrical, or nearly spherical, but a few genera are lenticular or subspherical with axis of coiling the shortest diameter; bilaterally symmetrical, spirally enrolled, completely involute, with only the spiral wall (*spirotheca*) and the last septum (*antetheca*) visible on the exterior; exterior divided into numerous melonlike lobes (corresponding to chambers) that extend from pole to pole; ratio of equatorial diameter to axial length is known as *form ratio.* (See text Figs. 2–5.)

Volutions numerous, commonly 5 to 15, and subdivided by septa into numerous slender chambers that extend from pole to pole; septa nearly plane in some genera, but in others deeply and regularly *plicated* at the lower margin into curtainlike folds that partly subdivide the chamber into *chamberlets*; folds of adjacent septa always oppose; opposing folds in many forms join at their bases, and in two genera the junctions form vaulted arched tunnels (*cuniculae*) between alternate chambers; morphology of chambers strictly subordinated to shell architecture.

Shell walls calcareous and porous; spirothecal pores fine to extremely fine and very closely spaced, making the wall appear like honeycomb; septal pores medium sized, more widely spaced; spiral and septal walls composed of one or more layers — the primary wall (*protheca*) and, in many genera, a veneer of dense and dark secondary deposition (*epitheca*) on one or both sides of the primary wall.

The principal early and middle Pennsylvanian genera, notably *Staffella*, *Fusulinella*, *Fusulina*, and *Wedekindellina*, have the fusulinellid wall structure The primary wall in the spirotheca consists of a thin diaphanous layer (10 to 20 microns across), the *diaphanotheca*, which is penetrated by extremely fine, simple pores. Lagging a few chambers or a volution behind the erection of the primary shell structure, a veneer of epitheca is deposited on the floor, sides, and ceiling of the chambers; thus the walls of the inner volutions come to have a three-ply appearance, with the more diaphanous protheca in the middle. Protheca of septa (*pyknotheca*) is composed of same substance as diaphanotheca but lacks fine honeycomb structure. Locally in some individual shells and commonly in some species a very thin dark zone (loosely called the *tectum*) forms a sort of rind on the outside of the protheca. This is probably both a sutural and an epithecal contact zone, therefore both primary and secondary in origin.

The principal upper Pennsylvanian and Permian genera have a schwagerinid or keriothecal wall structure in which the spiral wall is composed of thick to very thick (25 to 150 microns), rather coarsely porous, honeycomblike protheca (*keriotheca*). Locally or generally in some forms the outside of the keriotheca bears a very thin zone or rind in which the spirothecal pores are constricted to a very fine pore or are divided into smaller pores. This zone, also called the tectum, commonly seems to belong to the protheca, but locally belongs to the epitheca. So the partial closures of the outer end of the spirothecal pores produce an alveolar structure that more closely resembles honeycomb than the simple pores in the fusulinellid wall.

A large equatorial canal or tunnel is formed by resorption through the base of all but the last few septa. Angular width of tunnel (*tunnel angle*) is measurable only in axial section with proloculum as apex of angle. In many genera both sides of tunnel bounded by a leveelike deposit of epitheca (*choma*, plural *chomata*). One genus and some species of other genera fill polar zones of early volutions with epitheca. Maintenance of open pores of all kinds differs greatly among genera and species, and location of open pores differs within individual shells.

Evolution rapid; extremely prolific in number of individuals and preeminent as organic lime-depositing agents; genera and species numerous, many having short vertical range; shell growth commonly

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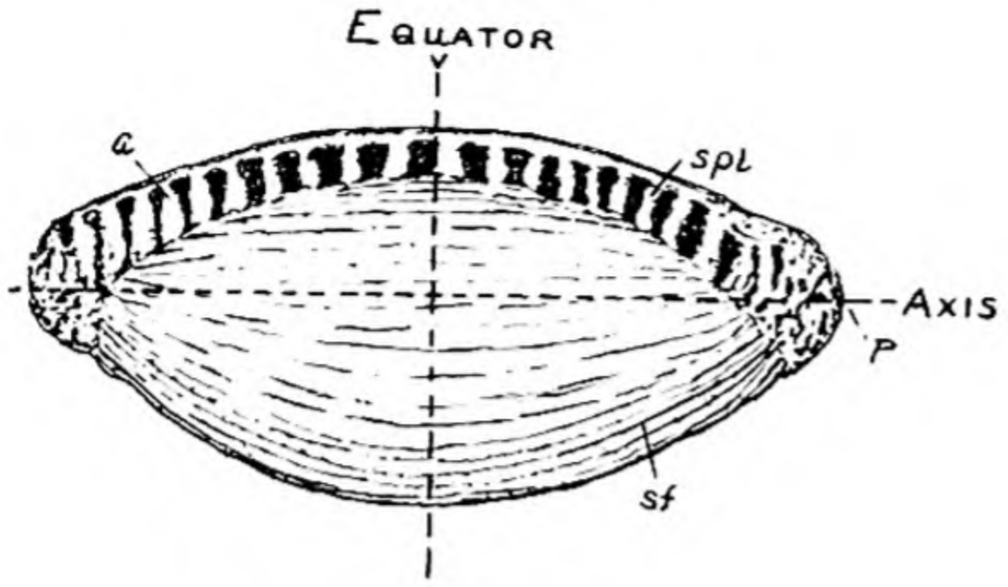

FIG. 2. External features.

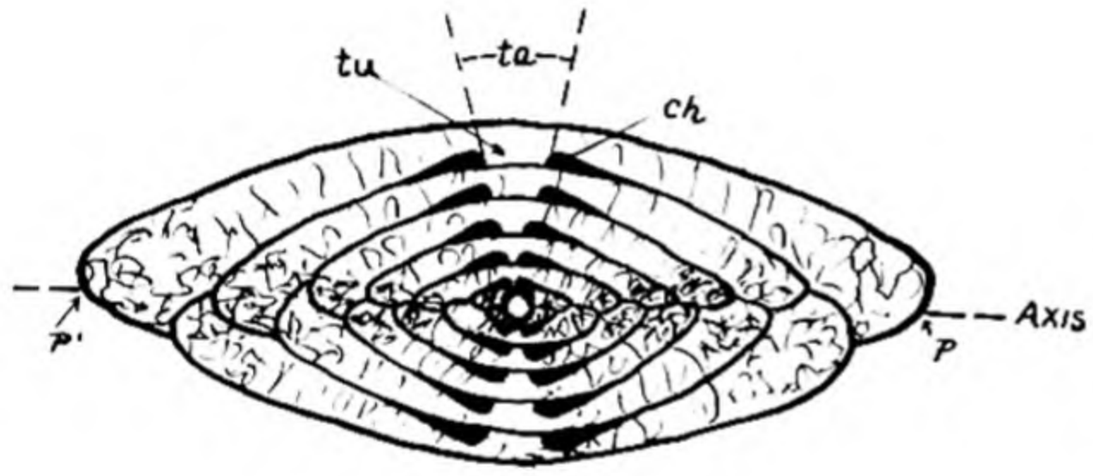

FIG. 3. Diagrammatic axial section.

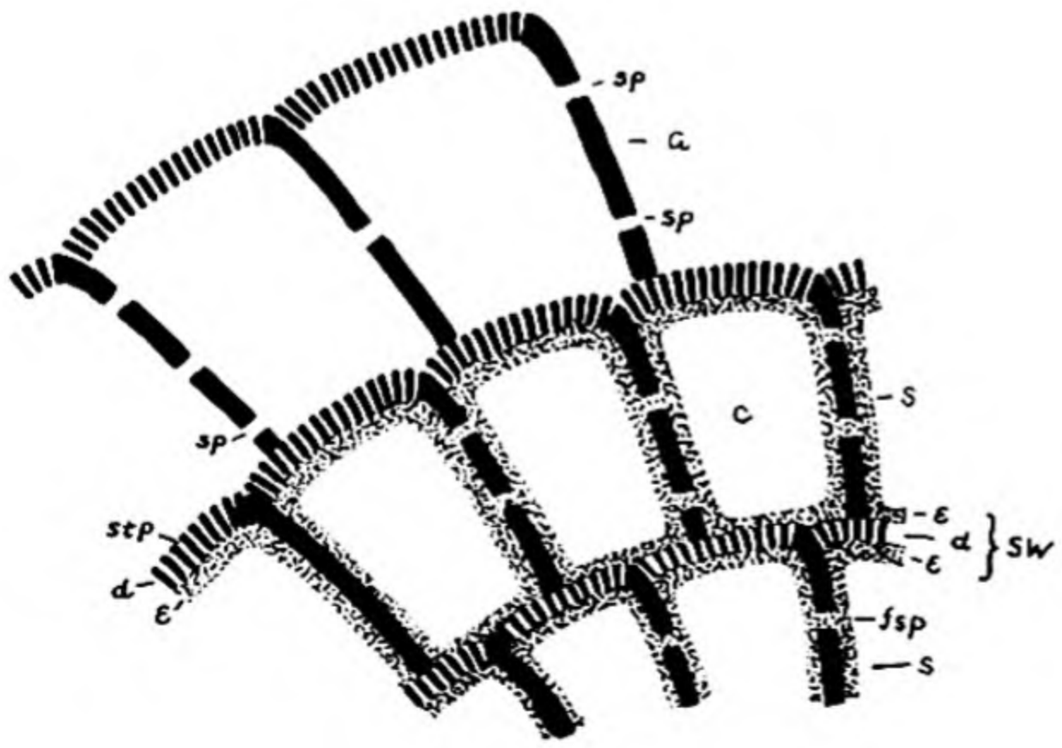

FIG. 4 Fusulinellid wall structure.

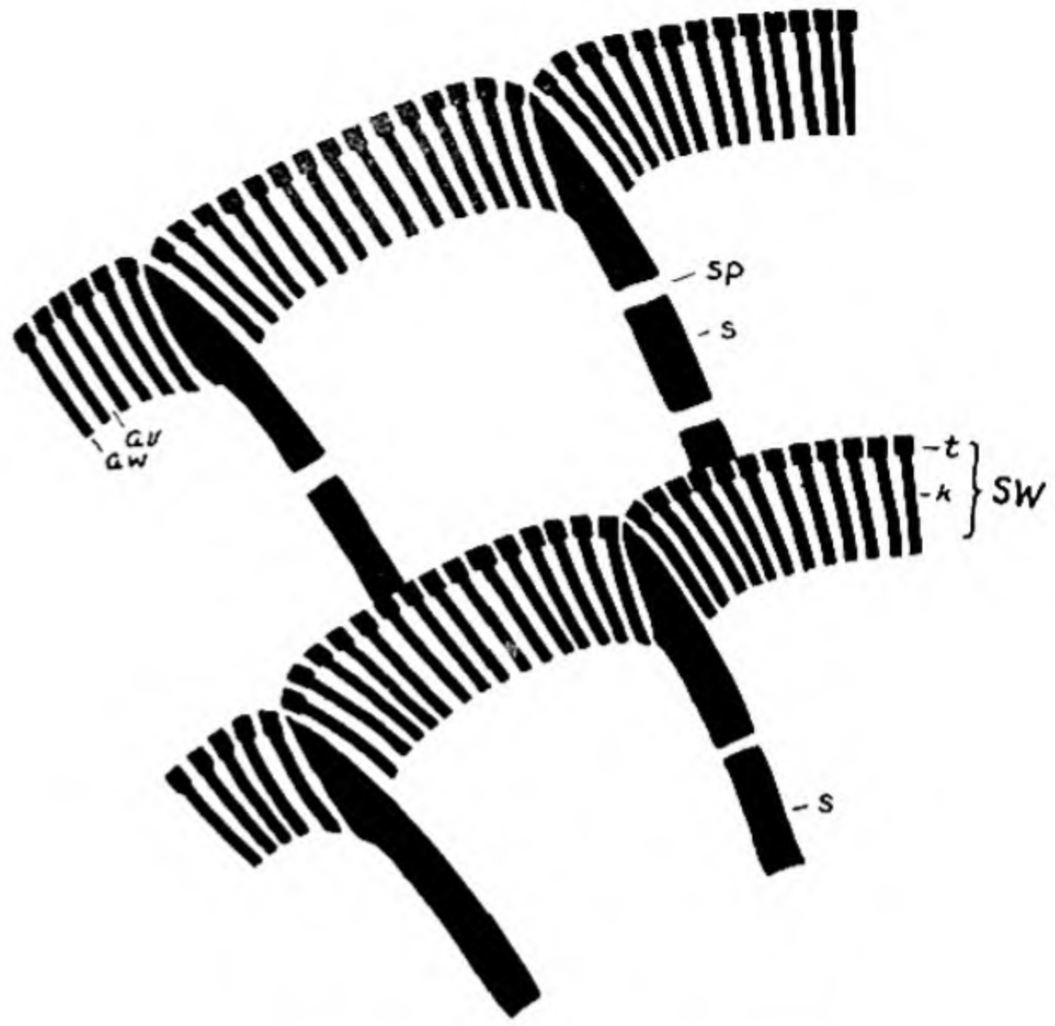

FIG. 5. Schwagerinid or keriothecal wall structure.

KEY

a, Antetheca, the last and only exposed septum, composed of pyknotheca and penetrated by septal pores; *av*, alveolus, a large and specialized spirothecal pore; *aw*, alveolar wall; *c*, chamber; *ch*, choma (plural chomata); *d*, diaphanotheca, the primary layer (protheca) of the spiral wall; *e*, epitheca, a veneer of secondary wall deposition, absent from the last few chambers during progress of shell growth; *fsp*, septal pore filled with epitheca; *k*, keriotheca; *p*, pole; *s*, septum; *sf*, septal furrows; *sp*, open septal pore; *spl*, septal plication; *stp*, spirothecal pore; *sw*, spiral wall or spirotheca; *t*, tectum; *tu*, tunnel; *ta*, tunnel angle. (The tectum was omitted from the figure of the fusulinellid wall. Wherever present it is commonly obscure or absent or at best is a very thin dark indistinct zone on the outside of the diaphanotheca and front side of the pyknotheca or in the base of the adjacent epitheca. It is evidently heterogeneous and probably in part represents merely a contact zone at sutures or between shell lamellae.)

divisible into prolocular, juvenarial, and mature or adult, and rarely additional stages; dimorphism recognized in several genera; in forms with clearly recognized dimorphism, shells of megalospheric generation vastly outnumber microspheric.

Precisely oriented and centered sections in two directions required for identification; axial section intersects the axis and proloculum; equatorial section intersects the proloculum but is perpendicular to the axis. Among important features to be considered in specific determinations are external size and shape, form ratio, degree and distribution of septal plication, closeness of coiling or ratio of number of volutions to diameter of shell, shape and size of chomata if present, tunnel angle, changes in rate or character of growth, thickness and distribution of epitheca, thickness of protheca, number of septa per volution, peculiarities in juvenarium, and size of proloculum.

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Habitat marine; apparently benthonic in middle and lower parts of zone of light penetration.

Probably present in **Mississippian;** especially abundant in and characteristic of the marine **Pennsylvanian** and **Permian** of the world.

STAFFELLA Ozawa 1925

(**Fusulina sphaerica* Abich [controversial]). Minute to small; subspherical, with axis commonly the shortest diameter; number of volutions and septa small to moderate; septa plane; spiral wall fusulinellid; chomata present; tunnel commonly narrow; juvenarium and adult stages commonly intergradational. **Penn., Perm.** of world.

S. hollingsworthi Thompson (**3**—39–43). Minute, subspherical, with umbilici; shell growth rather irregular; 10 septa in first volution, 14 in second, 16 in third; 3 to 4 volutions; chomata low but wide; tunnel rather wide for genus; epitheca moderately thick. This and closely similar species common in Atoka and L. Cherokee, **Penn.:** Okla. and Colo.

FUSULINELLA Möller 1876

(**F. bocki*). Small, fusiform to ventricose; number of volutions and septa moderate to rather numerous, tightly coiled; septa generally plane in central region, more or less irregularly plicated in polar zones; walls fusulinellid; epitheca massive, particularly on floor and sides of chambers; chomata massive and very broad; little or no filling of polar zones with epitheca. **Penn., Perm.** (most common and characteristically developed in early Pennsylvanian).

F.? primaeva Skinner (**3**—37, 38). Minute, length 3 mm and equatorial diameter 1.4 mm; ventricosely fusiform, form ratio about 1: 2.2; septa plicated in end zones; 14 septa in third and 16 in sixth volutions; tunnel very wide throughout, angle more than 50°; chomata rather low and narrow; epitheca rather thin; juvenarium somewhat endothyroid. **Penn.** (Morrow): Tex. (Marble Falls), Wyo.?

F. iowensis Thompson (**3**—33, 34). Medium size, very ventricose; about 10 volutions; septa numerous, about 25 in fifth to 36 in eighth volutions; epitheca thin on ceiling of chambers, elsewhere massive. **Penn.:** Ohio (Mercer), Ill. and Ia. (Seville).

F.? serotina Thompson (**3**—35, 36). Small, ventricosely fusiform; length 4.4 mm, diameter 1.4 mm; form ratio 1:3; volutions about 7; number of septa in volutions 3, 5, and 7 are 16, 24, and 31 respectively; septa rather deeply but irregularly plicated; epitheca rather thick. **Penn.** (L. Des Moines or U. Atoka): Ohio (Putnam Hill), Okla.?, Wyo. (Hartville), Nev.

F.? dakotensis Thompson (**3**—30–32). Resembles *F.? serotina* but ends more acutely pointed and more slender; walls thinner; more tightly coiled. **Penn.** (L. Des Moines or U. Atoka): S. Dak. (L. Minnelusa), Nev.?

WEDEKINDELLINA Dunbar and Henbest 1933

(**Fusulinella euthysepta* Henbest). Minute to small; fusiform to ventricosely ellipsoidal; number of volutions and septa great in proportion to size; very closely coiled; septa generally plane with rudimentary or irregular plications in end zones of later volutions of some species; walls fusulinellid, epithecal veneer and chomata massive; polar zones, except first and last volutions, commonly filled with epitheca; tunnel narrow; juvenarium and later stages intergradational. **Penn.** (Des Moines and rarely Missouri) of U. S. A. and Eurasia.

***W. euthysepta** (Henbest) (**3**—27–29). Minute, fusiform with acutely pointed ends; average length 4 mm, diameter 1.0 to 1.2 mm, form ratio approximately 1:4; 8 to 11 volutions; epithecal filling of polar zones well developed. **L. Des Moines:** Ill. (Stonefort, Seahorne, and Oak Grove), Ia., Kan., Okla., Colo., Tex., Wyo., N. Mex.

FUSULINA Fischer 1829

(**F. cylindrica*). Small to medium sized; fusiform, cylindrical, to ventricosely fusiform; proloculum small, commonly 75 to 150 microns across; number of volutions moderate to rather numerous; number of septa per volution moderate; septa slightly to very deeply and regularly plicated; walls fusulinellid but generally with relatively thin epitheca; chomata narrow; juvenarium commonly recapitulates *Fusulinella*; dimorphism recognized. **L.?** and **M. Penn.**

F. leei Skinner (**3**—25, 26). Small, fusiform; length 4 to 5 mm, diameter about 1.7 mm, form ratio 1: 2.7; volutions 7 to 8; septa deeply and regularly plicated; epitheca rather thick. **L. Des Moines:** Ohio?, Ill. (Curlew), Ia., Kan., Okla. (Bluejacket), Wyo.?.

F. novamexicana Needham (**3**—23, 24). Resembles *F. girtyi* but less ventricose, septal plication more irregular, and less closely coiled in later volutions. **L. Des Moines:** Ill. (Stonefort), Mo., Kan.?, Okla., N. Mex.

F. haworthi Beede (**3**—18, 19). Very ventricose; length 6 to 7, rarely 8 mm, diameter 2.5 to 3.0 mm, form ratio 1: 2.4 to 1: 2.7; resembles *F. girtyi* but less spherical, less closely coiled, and with thinner walls from having thinner epitheca. **M.** and **U. Des Moines:** Ind.?, Ill. (U. Carbondale and L. McLeansboro), Ia., Mo., Kan. (L. Fort Scott).

F. girtyi (Dunbar and Condra) (**3**—21, 22). Very ventricose to subspherical; length 4 to 4.5 mm, diameter 2.5 to 3.0 mm, form ratio 1:1.5; chambers very numerous, coiling very close; septa very deeply and closely plicated; tunnel narrow; epitheca rather thick, widely distributed, particularly massive near equatorial zone. **M. Des Moines:** Ill. (U. Carbondale, L. McLeansboro), Ia., Mo., Kan. (Fort Scott).

F. eximia Thompson (**3**—15, 20). Cylindrical; large; length 7 to 9 mm, diameter 1.7 to 2.1 mm, form ratio 1: 3.5 to 1: 4.4; septa rather numerous, coiling close; septa very deeply plicated; tunnel narrow in early, very wide in later volutions; walls thin; epitheca very thin; chomata narrow in later volutions. In septal evolution corresponds to latest *Schwagerina* and earliest *Parafusulina* but distin-

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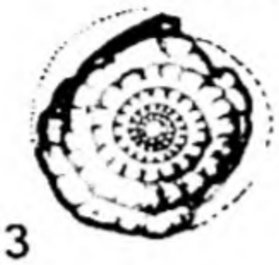
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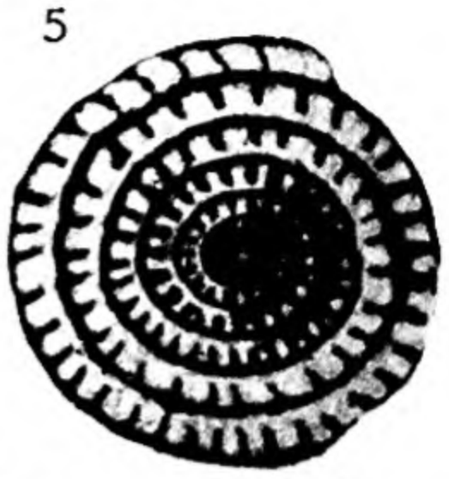
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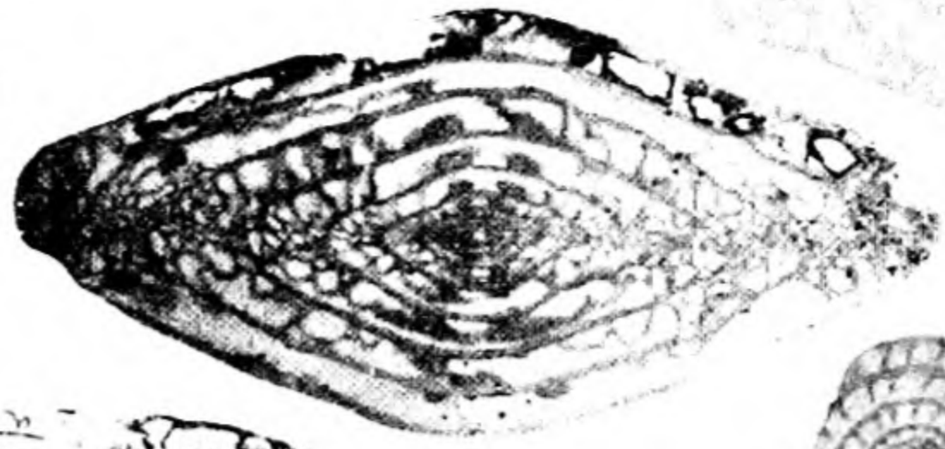
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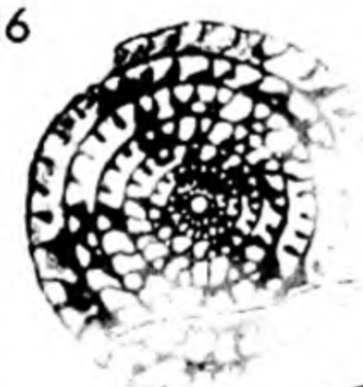
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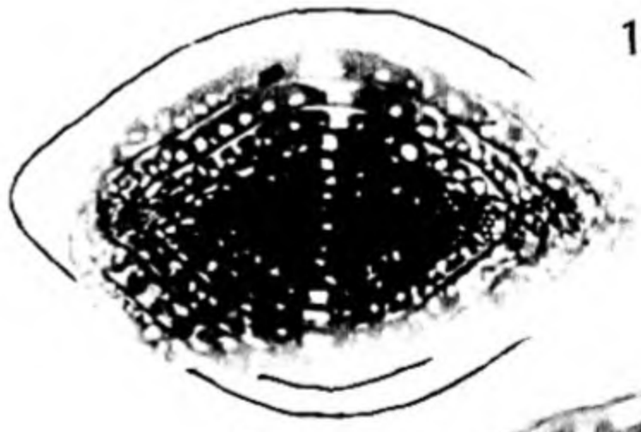
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guishable from those by presence of chomata and fusulinellid wall structure. **U. Des Moines:** Ind.?, Ill. (Piasa), Ia.

F. acme Dunbar and Henbest (**3**—16, 17). Medium size, subcylindrical; resembles *F. eximia* but slightly more fusiform and much shorter; average length 6 mm, diameter 2.3 mm, form ratio 1: 2.6; last 2.5 to 3.5 volutions suddenly increased in rate of axial and equatorial growth; represents highest grade of septal evolution so far known in *Fusulina*; may have rudimentary cuniculae. This and *F. eximia* closely resemble *F. cylindrica* Fischer, **U. Moscovian,** U. S. S. R., and **U. Penchi** and **U. Huanglung,** China. At top of Fusulina zone, **U. Des Moines:** Ill. (Lonsdale), Ia.?.

TRITICITES Girty 1904

(**Miliolites secalicus* Say). Medium to large; fusiform, cylindrical, or ventricose; proloculum medium sized; septa plicated; spiral wall composed mainly of thick, honeycomblike keriotheca, commonly 30 to 100 microns thick; epitheca generally thin or obscure, but massive in a few species; vast majority of individuals megalospheric. **U. Penn.** (Missouri and Virgil) to **L. Perm.** (L. Wolfcamp) of world.

T. ohioensis Thompson (**3**—13, 14). Cylindrical, cigar-shaped; length 9 mm, diameter 2 mm, form ratio 1: 4.5; chomata large, broad; tunnel in later volutions broad; epitheca thick; keriotheca rather thin, but honeycomb structure is distinct; septal folding rather deep but somewhat irregular. **Penn.** (Missouri): Ohio (Cambridge), Ill. (Livingston), Ia.?, Kan.

T. osagensis Newell (**3**—11, 12). Resembles *T. ohioensis* in form and external proportions but longer and more slender; average form ratio 1: 5.7; septa more deeply plicated. **Penn.** (Missouri) (near or slightly higher than horizon of *T. ohioensis*): Kan., Okla., Tex.

T. secalicus (Say) (**3**—9, 10). Large, fusiform, with pointed ends; length 8 to 11 mm, diameter 2.8 to 3.2 mm, form ratio near 1: 3; septa but moderately plicated, opposed folds not always joining; chomata well developed. **Penn.** (Virgil): Ill.?, Mo., Neb. and Kan. (Shawnee, Douglas, and Lansing), Tex. (Graham).

T. cullomensis Dunbar and Condra (**3**—5, 6). Medium size; fusiform; length 5 to 6.5 mm, diameter 2 to 3 mm, average form ratio approximately 1: 2.5; septa rather widely spaced and but slightly plicated; keriotheca 0.08 to 0.11 mm thick in later volutions; tunnel angle commonly 40° to 50°. **Penn.** (Virgil): Mo., Neb., Kan. (Shawnee and Wabaunsee), Tex. (Cisco).

T. moorei Dunbar and Condra (**3**—3, 4). Small; subcylindrical with blunt ends; length 4.8 to 5.4 mm, diameter 1.8 to 2 mm, form ratio 1: 2.7; number of volutions small, commonly 5; septa moderately plicated, rather widely spaced; species especially characterized by rapid expansion in length and loose coiling after first or second volution; commonly associated with *T. beedei* and *T. plummeri* though the last species extends somewhat higher. **Penn.** (Virgil): Kan.?, Tex. (Graham).

T. beedei Dunbar and Condra (**3**—7, 8). Medium size; very ventricosely fusiform with pointed ends; length 6 to 7.6 mm, diameter 2.7 to 3.8 mm, form ratio 1: 1.5 to 1: 2.0; septa slightly plicated in central region; keriotheca moderately thick; epitheca much less massive and widely distributed than in *T. plummeri*. **Penn.** (Virgil): Shawnee of Mo., Neb., Kan.; Tex. (Graham).

T. plummeri Dunbar and Condra (**3**—1, 2). Large, very ventricose to subspherical; length 5 to 6 mm, diameter 3 to 3.6 mm, form ratio 1: 1.5; septa deeply plicated; keriotheca very thick, alveoli large; chomata and epithecal veneer much more massive than common in *Triticites*. **Penn.** (Virgil): Neb. (Shawnee), Tex. (U. Graham).

T. tumidus Skinner (**4**—30–32). Large, ventricose, with central region inflated; length 8 to 12 mm, diameter 3.8 to 5 mm, form ratio near 1: 2.5; keriotheca relatively thin; epitheca widely distributed; closely coiled, commonly 10 volutions. This and closely similar species are characteristic of the basal **Perm**. (Wolfcamp): Kan. and Okla. (Foraker and Neva), north-central Tex. (Stockwether and Saddle Creek), N. Mex.

T. ventricosus (Meek and Hayden) (4—34–36). Large, ventricose; length 9 to 12 mm, diameter 4 to 5 mm, form ratio 1: 2.3 to 1: 2.5; 8 to 10 volutions; proloculum 0.12 to 0.36 mm across; keriotheca very thick, commonly 0.08 to even 0.14 mm in later whorls; chomata rather prominently developed; epithecal veneer very thin or absent. **U. Penn.** to **L. Perm.** (Wolfcamp): Neb., Kan., Okla., Tex., N. Mex., Utah?

SCHWAGERINA Möller 1877

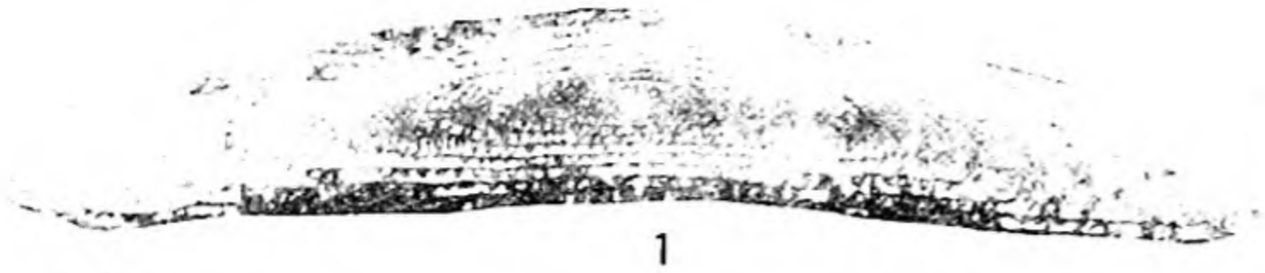
(**Borelis princeps* Ehrenberg). Medium to extremely large; fusiform, cylindrical, or ventricose; shell

PLATE 3

Pennsylvanian Fusulinidae. Species are arranged approximately in relative stratigraphic position, with earliest at base of plate. Plate prepared by L. G. Henbest.

[Figures are x10 and original by Henbest unless otherwise indicated; D and C = Dunbar and Condra [Neb G S, B 2].]

1–14. Triticites spp. 1, 2. T. plummeri [D and C]. **3, 4. T. moorei. 5, 6. T. cullomensis** [D and C]. **7, 8. T. beedei** [D and C]. **9, 10. T. secalicus** [9, D and C]. **11, 12. T. osagensis** [JP 8]. **13, 14. T. ohioensis** [JP 10]. **15–26. Fusulina spp. 15, 20. F. eximia** [U Ia Stud N H 16]. **16, 17. F. acme** [Dunbar and Henbest]. **18, 19. F. haworthi. 21, 22. F. girtyi. 23, 24. F. novamexicana. 25, 26. F. leei. 27–29. Wedekindelina euthysepta** (Fig. 29 (x48) shows central region of Fig. 28; *t*, tunnel, *ch*, choma). **30–38. Fusulinella spp. 30–32. F.? dakotensis** [JP 10]. **33, 34. F. lowensis** [U Ia Stud N H 16]. **35, 36. F.? serotina** [JP 10]. **37, 38. F.? primaeva. 39–43. Staffella hollingsworthi** [JP 9].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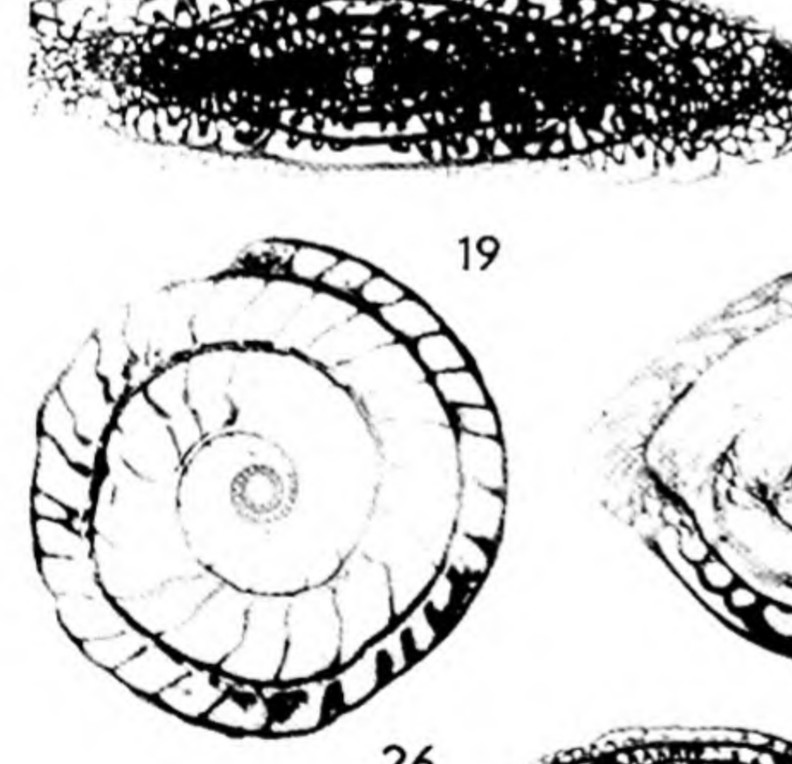
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structure like that of *Triticites* but lacks chomata in adult stage; some species have epithecal filling in axial zone. **L.** and **M. Perm.** of world.

S. emaciata (Beede) (4—27, 33). Medium size, fusiform, with rather pointed ends; length 5 to 6 mm, diameter about 2 mm, form ratio 1:3; walls rather thin; septa deeply though somewhat irregularly plicated. **Perm.** (L. Wolfcamp): Neb., Kan., Tex., N. Mex.

S. huecoensis (Dunbar and Skinner) (4—18–20). Large, fusiform; length 12 to 15 mm, diameter 3 to 4 mm, form ratio about 1:4; septa rather numerous, very deeply and narrowly plicated; 5 to 6.5 volutions; keriotheca thick in last 4 to 5 volutions. This and very closely similar species in **Perm.** (Wolfcamp): Neb., Kan., Okla., Tex., N. Mex.

S. setum Dunbar and Skinner (4—13–15). Extremely large, cylindrical; length about 20 mm, diameter 4.5 mm, form ratio 1:4.5 to 1:5; about 9 volutions; chambers numerous; walls thin; septal plications very deep, regular, and crowded; resembles *Parafusulina* but lacks cuniculae. **Perm.** (Leonard): Tex. (Bone Spring). Similar forms in Albert Land, Arctic America.

PSEUDOSCHWAGERINA

Dunbar and Skinner 1936

(**Schwagerina uddeni* Beede). Large to extremely large, ventricose to spherical; epitheca extremely thin or absent; septa widely spaced in adult stage; septa thin, plication slight and commonly irregular; opposing plications of adjacent septa rarely fuse; juvenarium very closely coiled and distinct from loosely coiled adult stage; chomata absent in adult stage. Widely distributed and characteristic of **Perm.** (Wolfcamp) of world. (Generally but erroneously known as "*Schwagerina*" before 1936.)

***P. uddeni** (Beede) (4—25, 26). Very large, nearly spherical, with protruding poles; length 8 to 10 mm; spiral wall rather thin; septa waver in trend, irregularly and but slightly plicated in central region; commonly 5, sometimes 6 volutions; juvenarium very closely coiled, commonly containing 1.5 to 2.5, rarely 4 volutions; later volutions very loosely coiled, with septa widely spaced; change from juvenarium to subsequent volutions extremely abrupt; chomata prominent in juvenarium, absent thereafter. **Perm.** (Wolfcamp): Kan.?, Tex., N. Mex.

P. texana Dunbar and Skinner (4—28, 29). Large, ventricosely fusiform in all volutions; length 10 to 12 mm, diameter 4.5 to 5 mm; 5 or 6 volutions; poles rather sharp; juvenarium 2.5 to 4 volutions, closely coiled, later volutions rather loosely coiled; keriotheca thick, 0.09 to 0.12 mm in last volutions; septa rather deeply plicated at base, but wide spacing of septa introduces irregularity in fusion of opposed folds; closely resembles "*Schwagerina*" *fusulinoides* Schellwien in the Carnic Alps. **Perm.** (Wolfcamp): N. Mex. and west Tex. (Hueco), north-central Tex. (Horse Creek).

PARASCHWAGERINA Dunbar and Skinner 1936

(**Schwagerina gigantea* White). Closely resembles *Pseudoschwagerina* but has deeply and regularly plicated septa, with fusion of opposed plications; chomata poorly developed in juvenarium and absent thereafter. **Perm.** (Wolfcamp).

***P. gigantea** (White) (4—21, 22). Very large, ventricosely fusiform with pointed ends; average length 12 mm (maximum about 15 mm), diameter 5 to 6 mm; 8 to 10 volutions; septa numerous, deeply and regularly plicated; equatorial expansion or height of septa changes but little during adult stage. **Perm.** (Wolfcamp): West Tex.; similar form, north-central Tex. (Horse Creek).

P. kansasensis (Beede and Knicker) (4—23, 24). Large, spherical, with poles protruding; length about 8 mm, diameter 6 to 6.5 mm; 8 to 10 volutions; proloculum very small, 0.06 to 0.11 mm; 3.5 to 4 very closely coiled volutions in juvenarium; keriotheca thin in juvenarium and early adult stages but reaches a thickness of 0.08 to 0.10 mm in later stage. **Perm.** (Wolfcamp): Kan., Okla., Tex.

PARAFUSULINA Dunbar and Skinner 1931

(**Parafusulina wordensis*). Like *Schwagerina* but septal plication more highly specialized; possesses cuniculae. **Perm.** (Leonard and Guadalupe): (N. America; Eurasia).

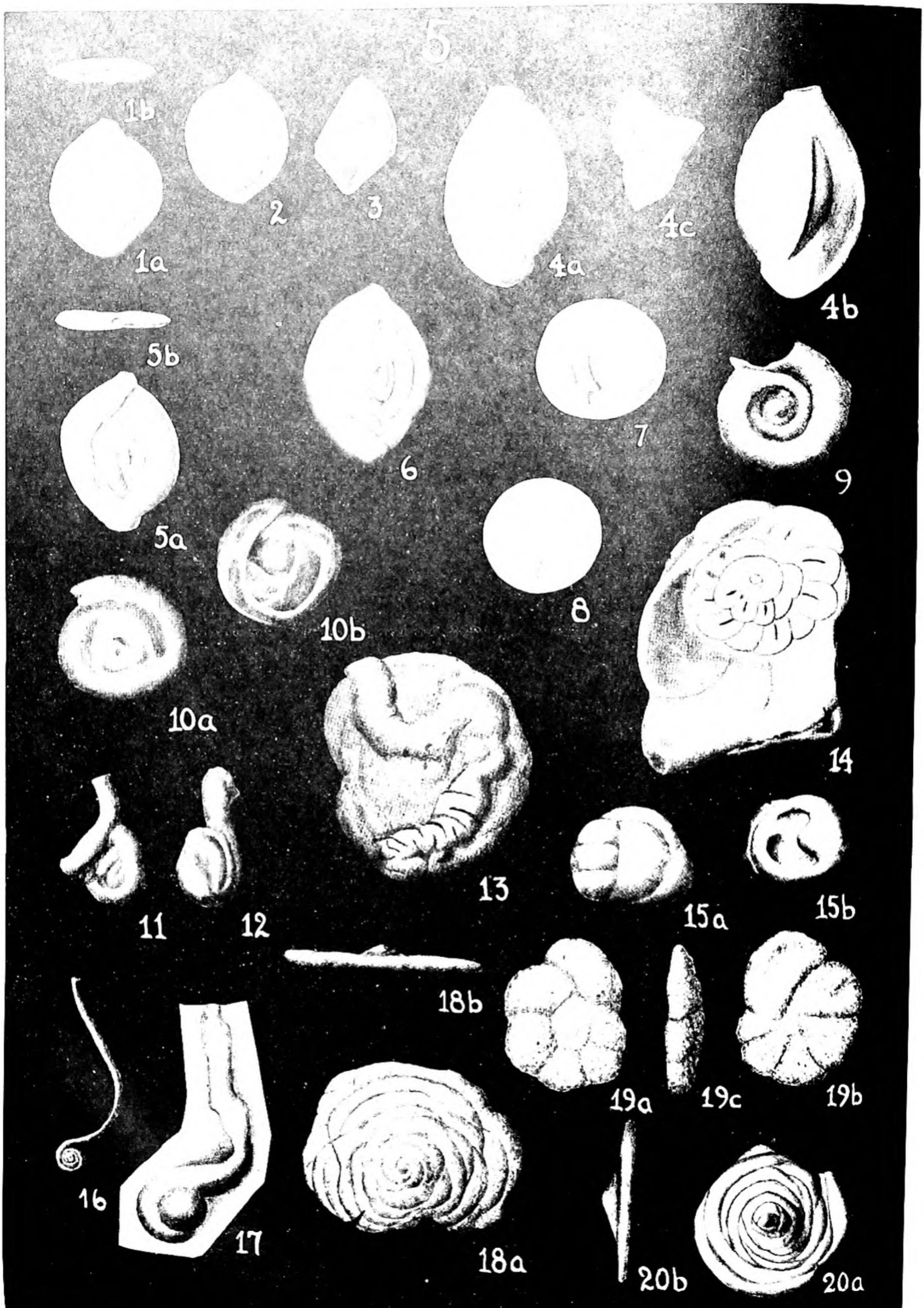
P. diabloensis Dunbar and Skinner (4—16, 17). Large, ventricosely fusiform; length about 13 mm, diameter 4.5 to 5 mm, form ratio 1:2.5 to 1:2.7; proloculum large, 0.4 to 0.5 mm; septa numerous; axial zone filled with epitheca. **Leonard:** Tex. (Bone

PLATE 4

Permian Fusulinidae. Species arranged approximately in relative stratigraphic position, with earliest at base of plate. Plate prepared by L. G. Henbest.

[Figures are x5 and after Dunbar and Skinner [U Tex B 3701] unless otherwise indicated.]

1, 2. Polydiexodina capitanensis. 3–12, 16, 17. Parafusulina spp. 3–6. P. lineata (5 and 6, x2.5). **7–9. P. sellardsi.** (8: tangential section showing septal folding; A, upper part of several septa showing meridional or axial trend characteristic of family; C, middle part of septa where deep plications fuse to form chamberlets; S, lower margin of septa having spiral trend as result of extreme plication and formation of cuniculae.) **10–12. P. rothi.** (12: central part of a microspheric individual showing extremely close spacing of septal plications.) **16, 17. P. diabloensis. 13–15, 18–20, 27, 33. Schwagerina spp. 13–15. S. setum. 18–20. S. huecoensis. 27, 33. S. emaciata. 21–24. Paraschwagerina spp. 21, 22. P. gigantea. 23, 24. P. kansasensis. 25, 26, 28, 29. Pseudoschwagerina spp. 25, 26. P. uddeni. 28, 29. P. texana. 30–32, 34–36. Triticites spp. 30–32. T. tumidus. 30, 32** [JP 5]; **31,** same specimen as Fig. 30, but x10 to show thin keriotheca. **34–36. T. ventricosus** [34, 35, Dunbar and Condra: Neb G S, B 2; 36, Henbest photomicrograph of another specimen from Kansas, x24].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Spring). (More or less similar species of *Parafusulina* with axial filling widely distributed in **M. Perm.** of Central America, Tex., Ore. Forms with massive epithecal filling but belonging to *Schwagerina*, notably *S. compacta* (White), are common in the Wolfcamp of Texas. Absence of cuniculae serves to distinguish those *Schwagerina* from the higher forms.)

P. rothi Dunbar and Skinner (4—10–12). Very large, elongated; microspheric generation is slender and cylindrical, the megalospheric more fusiform and less slender; length about 15 or 16 mm, diameter 3.5 to 4 mm, form ratio near 1: 5; maximum thickness of keriotheca about 0.09 mm; septa numerous, plications even and crowded. **U. Perm.:** Tex. (U. Word), N. Mex.

P. lineata Dunbar and Skinner (4—3–6). Large, extremely slender; length 14 mm, diameter 2 to 2.4 mm; volutions 7 to 8, very closely coiled; septa numerous and very deeply plicated; tunnel 55° to 60° wide in later volutions; walls thin; slight epithecal filling; resembles *Polydiexodina capitanensis* but is smaller, lacks multiple tunnels, and belongs lower in section; also resembles *Schwagerina linearis* Dunbar and Skinner very closely but latter lacks cuniculae except in last volutions of some specimens, has more distinct keriothecal wall structure, and belongs to topmost Wolfcamp. **U. Perm.:** Tex.

P. sellardsi Dunbar and Skinner (4—7–9). Extremely large, subcylindrical with broadly rounded ends; length 16 to 18 mm, diameter 4 to 5 mm; volutions 8 to 9; keriotheca 0.10 to 0.13 mm thick in later volutions; septa numerous, very deeply and closely plicated. **U. Perm.:** Tex. (Word).

POLYDIEXODINA Dunbar and Skinner 1931

(**P. capitanensis*). Resembles *Parafusulina* but has one or more pairs of supplementary tunnels resembling the equatorial tunnel but situated between it and the poles; has more or less axial filling. **U. Perm.:** Southwestern U. S. A.; Persia; Burma.

***P. capitanensis** D and S (4—1, 2). Very large; very slender, fusiform; length up to 22 mm, diameter about 3.5 mm, form ratio commonly 1: 5, 9 to 11 volutions; closely coiled; septa numerous; proloculum extremely large, 0.46 to 0.79 mm; spiral wall rather thin, not exceeding 0.06 mm. **U. Perm.:** Tex. (Capitan).

DESCRIPTIONS OF GENERA AND SPECIES—*Continued*

PREPARED BY JOSEPH A. CUSHMAN

RZEHAKINA Cushman 1927

(**Silicina epigona* Rzehak). Test planispiral, compressed, especially the central portion of each side; chambers each forming a half coil; wall finely arenaceous, siliceous, imperforate; aperture narrow, constricted, terminal. **U. Cret.**

R. epigona lata Cushman and Jarvis (5—1). **U. Cret.:** Trinidad.

SILICOSIGMOILINA Cushman and Church 1929

(**S. californica*). Test in early stages nearly planispiral, chambers a half coil in length, later added in varying planes and becoming sigmoid in end view; wall finely arenaceous, with siliceous cement; aperture rounded, terminal, without an apertural tooth. **U. Cret.**

***S. californica** C and C (5—2, 3). **U. Cret.:** Cal.

QUINQUELOCULINA Orbigny 1826

(**Serpula seminulum* Linnaeus). Test with coiling in five planes, the chambers a half coil in length, and added successively in planes 144° apart, five chambers completing a cycle of two turns about the axis in section, but two and a half coils lengthwise, each chamber 72° from its next adjacent one, but 144° from its immediate predecessor; wall with an interior chitinous layer outside of which is a calcareous imperforate layer, in some species with an outer layer of sand grains; aperture at end of chamber, rounded, typically with a simple tooth. **Carb.–Recent.**

Q. moremani Cushman (5—4). **U. Cret.:** Tex.

MASSILINA Schlumberger 1893

(**Quinqueloculina secans* Orbigny). Test with early chambers quinqueloculine, later ones added on opposite sides in a single plane; quinqueloculine stage present in both megalospheric and microspheric forms; walls often with an arenaceous layer; aperture simple, typically with a bifid tooth. **L. Cret.–Recent** (probably older).

M. pratti Cushman and Ellisor (5—5). **U. Eoc.:** La., Tex.

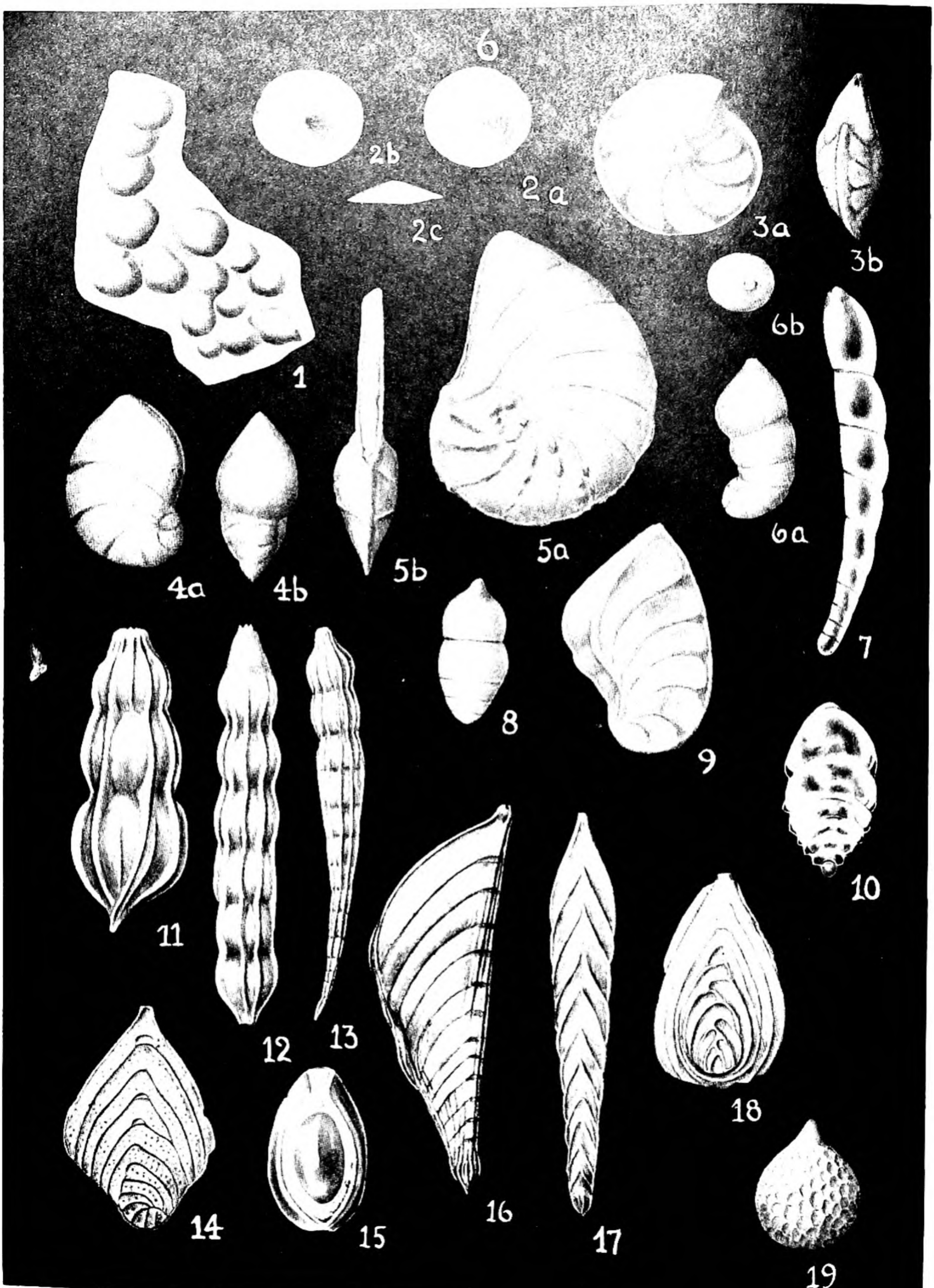
SPIROLOCULINA Orbigny 1826

(**S. depressa*). Test with early chambers in micro-

PLATE 5

[Figures are after Cushman unless other authorship is indicated in brackets. C and W = Cushman and Waters.]

1. Rzehakina epigona var. lata (x30) [Cushman and Jarvis]. 1a, 1b: side and apertural views. **2, 3. Silicosigmoilina californica** (x40) [Cushman and Church]. 2: side view; 3: transverse section. **4. Quinqueloculina moremani** (x90). 4a, 4b: opposite sides; 4c: apertural view. **5. Massilina pratti** (x40) [Cushman and Ellisor]. 5a, 5b: side and apertural views. **6. Spiroloculina wilcoxensis** (x90). **7, 8. Pyrgoella sphaera** (x35) [Flint]. **9. Cornuspira thompsoni** (x90) [C and W]. **10. Hemigordius calcareus** (x70) [C and W]. 10a, 10b: opposite sides. **11, 12. Orthovertella protea** (x90) [C and W]. **13. Calcivertella adherens** (x40) [C and W]. **14. Plummerinella complexa** (x75) [C and W]. **15. Globivalvulina biserialis** (x50) [C and W]. 15a, 15b: dorsal and ventral views. **16, 17. Apterrinella grahamensis** (x55) [C and W]. 16: microspheric; 17: megalospheric. **18. Polytaxis multiloculata** (x30) [C and W]. 18a, 18b: dorsal and peripheral views. **19. Trochammina diagonis** (x50). 19a, 19b, 19c: dorsal, ventral, and peripheral views. **20. Tetrataxis scutella** (x55) [C and W]. 20a, 20b: dorsal and peripheral views.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spheric form quinqueloculine, later ones in a single plane; in megalospheric form, quinqueloculine stage reduced or wanting; chambers a half coil in length; wall occasionally with an outer arenaceous layer; aperture usually with a neck and lip, simple, with a simple or bifid tooth. **Jura.–Recent.**

S. wilcoxensis Cushman and Garrett (5—6). **Eoc.:** Ala.

PYRGOELLA Cushman and White 1936

(**Biloculina sphaera* Orbigny). Test with earliest stages in microspheric form quinqueloculine, then triloculine, and later biloculine; chambers in adult with the last two making up the whole exterior, the final chamber inclosing all but a small rounded area of the next preceding; wall calcareous, imperforate, thin; aperture in early stages with a flattened, triangular tooth almost completely filling the opening, in the adult becoming Y-shaped, and in some specimens broken up into a series of 3, 4, or more elongate, often sinuous openings. **Late Tert.–Recent.**

***P. sphaera** (Orbigny) (5—7, 8). **Plioc.:** Cal.

CORNUSPIRA Schultze 1854

(**C. planorbis*). Test free, with a proloculum and long, planispirally coiled, second chamber, rounded or complanate; wall calcareous, imperforate; aperture formed by open end of chamber, sometimes constricted and with a thickened lip. **Carb.–Recent.**

C. thompsoni Cushman and Waters (5—9). **Penn.:** Tex.

HEMIGORDIUS Schubert 1908

(**Cornuspira schlumbergeri* Howchin). Test free, early coils not entirely planispiral, later planispiral and completely involute, but not umbonate; wall calcareous, imperforate; aperture formed by open end of tube. **Penn., Perm.**

H. calcareus Cushman and Waters (5—10). **Penn.:** Tex.

ORTHOVERTELLA Cushman and Waters 1928

(**O. protea*). Test free, early coils in varying planes, later portion uncoiled and more or less straight; wall calcareous, imperforate; aperture rounded, terminal. **Penn.**

***O. protea** C and W (5—11, 12). **Penn.:** Tex.

CALCIVERTELLA Cushman and Waters 1928

(**C. adherens*). Test attached, early portion close coiled, later uncoiling in short zigzag bends, forming a nearly even width to the test, later unbending; wall calcareous, imperforate; aperture rounded, terminal. **Penn., Perm.**

***C. adherens** C and W (5—13). **Penn.:** Tex.

PLUMMERINELLA Cushman and Waters 1928

(**P. complexa*). Test attached, early portion in a simple close planispiral, the coils in the adult composed of a zigzag, bent, tubular chamber, in last portion greatly expanded, on the dorsal side obscured by thickening, all stages of development on attached side; wall calcareous, imperforate; sutures somewhat limbate; aperture in early stages rounded, terminal, in an inflated chamber at outer angles. **Penn.**

***P. complexa** C and W (5—14). **Penn.:** Tex.

APTERRINELLA Cushman and Waters 1928

(**Tolypammina grahamensis* Harlton). Test attached; early portion in microspheric form consisting of proloculum and several close, planispiral coils; in megalospheric form the adult, irregular, tubular chamber starts abruptly with but a half turn about the large bulbous proloculum, adult chamber increasing rapidly in size; wall calcareous, imperforate, coarsely cancellated; aperture rounded, terminal. **Penn.–Jura.**

***A. grahamensis** (Harlton) (5—16, 17). **Penn.:** Okla., Tex.

TROCHAMMINA Parker and Jones 1859

(**Nautilus inflatus* Montagu). Test free or adherent, spiral, trochoid; chambers much compressed to nearly globular, all visible from dorsal side, only those of the last-formed whorl from the ventral; wall arenaceous, with chitinous base, amount of cement very variable; aperture an arched slit at inner margin of ventral side of chamber. **Penn.–Recent.**

T. diagonis Carsey (5—19). **U. Cret.:** Tex.; Mexico; western Canada.

GLOBIVALVULINA Schubert 1920

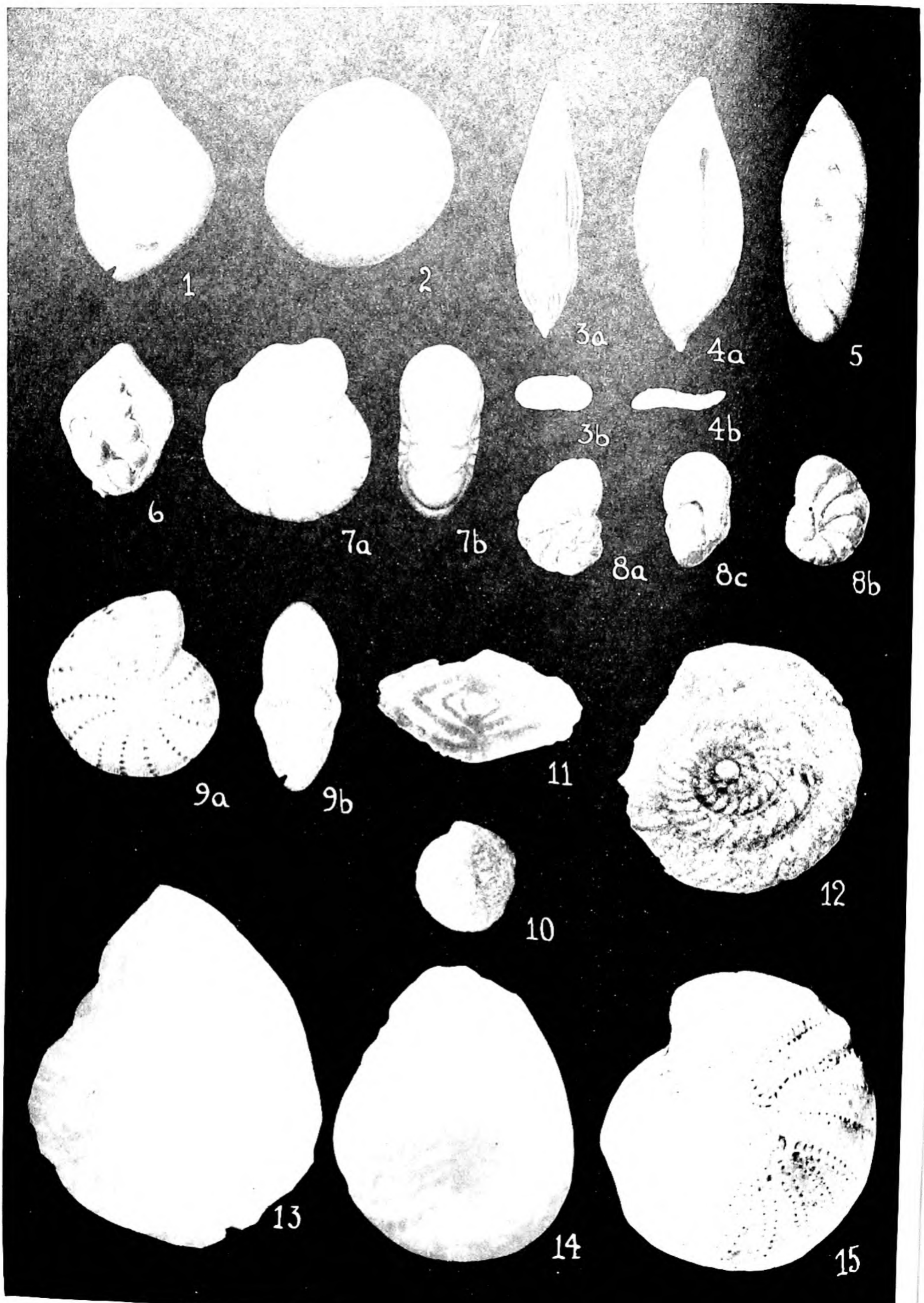
(**Valvulina bulloides* Brady). Test trochoid, subglobular or planoconvex, ventral side flattened, dorsal side strongly convex; chambers few, inflated; wall finely arenaceous, with much cement, often appearing to have a thickened inner wall and a thinner outer wall; aperture low, arched, at umbilical margin of chamber. **Penn., Perm.**

G. biserialis Cushman and Waters (5—15). **Penn.:** Okla., Tex.

PLATE 6

[Figures are after Cushman unless other authorship is indicated in brackets; C and J = Cushman and Jarvis.]

1. Placopsilina ciscoensis (x60) [Cushman and Waters]. **2. Orbitolina texana** (x3) [Carsey]. 2a, 2b, 2c: dorsal, ventral, and peripheral views. **3. Robulus navarroensis** (x30). 3a, 3b: side, apertural views. **4. Lenticulina navicula** (x40) [C and J]. 4a, 4b: side, apertural views. **5. Planularia advena** (x50) [C and J]. 5a, 5b: side, apertural views. **6. Marginulina bullata** (x50). 6a, 6b: side, apertural views. **7. Dentalina communis** (x35) [Cushman and Ponton]. **8. Pseudoglandulina conica** (x50) [Cushman and Barksdale]. **9. Saracenaria italica** (x25). **10. Linguilina taylorana** (x150). **11–13. Nodosaria affinis** (11, 12: megalospheric, x35; 13: microspheric, x30). **14. Palmula rugosa** (x40). **15. Entosolenia crumenata** (x90). **16. Vaginulina webbervillensis** (x20). **17. Frondicularia archiaciana** (x18). **18. Kyphopyxa christneri** (x30). **19. Lagena hexagona** (x70).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TETRATAXIS Ehrenberg 1843

(**T. conica*). Test conical, consisting of proloculum and elongate second chamber, later broken up into elongate, crescentic chambers; wall often with apparently two layers, an outer finely arenaceous one and the interior one clear and alveolar; aperture elongate, opening into the four-lobed umbilicus. **Penn., Perm.**

T. scutella Cushman and Waters (**5**—20). **Penn.: Tex.**

POLYTAXIS Cushman and Waters 1928

(**P. laheei*). Test in the early stages similar to *Tetrataxis*; earliest stage coiled, followed by elongate chambers in series of fours, then in the adult spreading; chambers numerous in each whorl, ventral side concave, irregular; apertures several, on ventral side. **Penn.**

P. multiloculata C and W (**5**—18). **Penn.:** Tex.

PLACOPSILINA Orbigny 1850

(**P. cenomana*). Test attached, composed of numerous chambers; early portion close coiled, later portions uncoiled and spreading out in a generally linear series; last chambers sometimes growing upward from the attachment; wall coarsely or finely arenaceous; aperture rounded, at end of last-formed chamber. **Sil.–Recent.**

P. ciscoensis Cushman and Waters (**6**—1). **Penn.: Tex.**

ORBITOLINA Orbigny 1850

(**O. gigantea*). Test depressed conical, lower side usually concave; early chambers in a depressed trochoid spire; later chambers covering entire base of test; ventral side usually convex, later becoming more or less annular; interior of chambers divided into chamberlets, outer portion with fine cellules, usually two rows to a chamber; wall with an outer, thin, imperforate, epidermal layer; inner wall finely arenaceous, with cement of lime or iron oxide; apertures, fine openings in somewhat radial lines, ventral. **Cret.**

O. texana Roemer (**6**—2). **L. Cret.:** Tex.

ROBULUS Montfort 1808

(**R. cultratus*). Test planispiral, bilaterally symmetrical, typically close coiled and involute; chambers numerous, triangular in side view; wall very finely perforate, glassy; aperture rounded in older forms, radiate in modern ones, the median slit enlarged in middle of end of apertural face. **Jura.–Recent.**

R. navarroensis (Plummer) (**6**—3). **U. Cret.:** Tenn., S. Dak., Neb., Kan., Ark., Tex.

LENTICULINA Lamarck 1804

(**L. rotulata*). Test similar to *Robulus*, tending to become uncoiled in some species; aperture radiate, at peripheral angle, slits equal. **Perm.–Recent.**

L. navicula (Orbigny) (**6**—4). **U. Cret.:** Trinidad.

PLANULARIA Defrance 1824

(**P. auris*). Test planispiral, bilaterally symmetrical, very much compressed, the sides nearly parallel; microspheric form more coiled in the young; aperture at peripheral angle, radiate, sometimes with ventral side expanded. **Jura.–Recent.**

P. advena Cushman and Jarvis (**6**—5). **U. Cret.:** Trinidad.

MARGINULINA Orbigny 1826

(**M. glabra*). Test subcylindrical, earliest portion close coiled, later uncoiled, final chambers often inflated; aperture radiate, in the early coiled portion as in *Lenticulina*, later becoming central and terminal. **Trias.–Recent.**

M. bullata Reuss (**6**—6). **U. Cret.:** Tenn., Fla.; Trinidad; Tex., Cal.

DENTALINA Orbigny 1826

(**Nodosaria (Dentalina) obliqua*). Test arcuate, elongate; chambers numerous in a linear series; sutures usually oblique, at least in early portion; aperture radiate, peripheral in early stages, later nearly central and terminal. **Jura.–Recent.**

D. communis Orbigny (**6**—7). **U. Cret.** and **Tert.:** Coastal Plain of U. S. A.

NODOSARIA Lamarck 1812

(**Nautilus radicula* Linnaeus). Test typically with chambers in a straight linear series, curved in early stages of microspheric form in many species, not strongly embracing; sutures in adult at right angles to axis; aperture terminal, radiate. **Trias.–Recent.**

N. affinis Reuss (**6**—11–13). **U. Cret.:** Tenn.; Cuba; Antigua; Trinidad; Ark., Tex.

PSEUDOGLANDULINA Cushman 1929

(**Nautilus comatus* Bartsch). Test similar to *Nodosaria*, but with chambers embracing, the last-formed one making up a large proportion of the

PLATE 7

[Figures are after Cushman unless other authorship is indicated in brackets; C and M = Cushman and McGlamery; C and O = Cushman and Ozawa.]

1. Guttulina problema (x70) [C and M]. **2. Globulina gibba** (x90) [C and M]. **3. Pseudopolymorphina rutila** (x65) [C and O]. 3a, 3b: side, basal views. **4. Sigmomorphina frondicularformis** (x35) [C and O]. 4a, 4b: side, basal views. **5. Polymorphina charlottensis** (x25) [C and O]. **6. Bulopora laevis** (x2) [Bagg]. **7. Nonion advenum** (x120) [C and M]. 7a, 7b: side, peripheral views. **8. Nonionella miocenica** (x50). 8a, 8b, 8c: dorsal, ventral, and apertural views. **9. Elphidium discoidale** (x80) [C and M]. 9a, 9b: side, apertural views. **10–12. Camerina matleyi** [Vaughan]. 10: exterior, x8.75; 11: vertical section, x29.75; 12: horizontal section, x29.75. **13. Operculina ocalana** var (x10). **14. Heterostegina ocalana** (x10). **15. Elphidiella hannai** (x27).

test; chambers uniserial throughout; aperture radiate, terminal. **Jura.–Recent.**

P. conica (Neugeboren) (6—8). **Eoc., Olig.:** Cuba; Mexico; Cal.

SARACENARIA Defrance 1824

(**S. italica*). Test with the earliest chambers close coiled, especially in the microspheric form, later uncoiling, usually triangular in transverse section; aperture radiate, at peripheral angle, median ventral slit usually enlarged. **Jura.–Recent.**

***S. italica** Defrance (6—9). **Cret.** and **Tert.:** Cuba; Fla., Gulf Coastal Plain, Neb.

LINGULINA Orbigny 1826

(**L. carinata*). Test in the early stages, at least in microspheric form, planispiral, later chambers in a rectilinear series, compressed; aperture becoming elongate, elliptical, terminal, with a tendency in some species to become radial or with teeth. **Jura.–Recent.**

L. taylorana Cushman (6—10). **U. Cret.:** Tex.

VAGINULINA Orbigny 1826

(**Nautilus legumen* Linnaeus). Test compressed, usually with one margin straight, representing the periphery in coiled forms, the other typically convex; early stages often somewhat coiled in microspheric form, sides flat or convex; aperture at peripheral angle, radiate. **Jura.–Recent.**

V. webbervillensis Carsey (6—16). **U. Cret.:** Tex.

PALMULA Lea 1833

(**P. sagittaria*). Test similar to *Frondicularia*, but with early chambers coiled both in microspheric and megalospheric forms. **Jura.–Recent.**

P. rugosa Orbigny (6—14). **U. Cret.:** Ala., Miss., Ark., Tex.

FRONDICULARIA Defrance 1826

(**F. complanata*). Test much compressed; in early stage in microspheric form, sometimes partly coiled; megalospheric form not coiled; later chambers extending back on the two sides of test to form inverted V-shaped (chevron-shaped) chambers; aperture terminal, radiate. **Jura.–Recent.**

F. archiaciana Orbigny (6—17). **U. Cret.:** Miss., Ark., Tex.

KYPHOPYXA Cushman 1929

(**Frondicularia christneri* Carsey). Test compressed; in the microspheric form with chambers as in the young of *Palmula*, later with a series of alternating biserial chambers; adult as in *Frondicularia*, or bending back at base, and with chambers overlapping; aperture terminal, radiate. **U. Cret.**

***K. christneri** (Carsey) (6—18). **U. Cret.:** Miss., Ark., Tex.

LAGENA Walker and Jacob 1798

(**Serpula (Lagena) sulcata*). Test consisting of a single chamber; wall calcareous, finely to coarsely perforate, often highly ornamented, with or without a neck; aperture radiate (rarely), rounded, elliptical or slitlike, terminal. **Jura.–Recent.**

L. hexagona (Williamson) (6—19). **U. Cret.** and **Tert.:** Coastal Plain of U. S. A.

GUTTULINA Orbigny 1839

(**Polymorphina (Guttulina) communis*). Test with chambers more or less elongated, added in planes 144° apart, i.e., in a quinqueloculine series; each chamber as added removed farther from the base. **Jura.–Recent.**

G. problema Orbigny (7—1). **Tert.:** Gulf Coastal Plain.

GLOBULINA Orbigny 1839

(**Polymorphina (Globulina) gibba*). Test globular or somewhat elongate, rounded or somewhat compressed in section; chambers somewhat quinqueloculine, but appearing triserial because of overlapping; sutures usually not depressed. **Cret.–Recent.**

***G. gibba** (Orbigny) (7—2). **Tert.:** Gulf and Atlantic Coastal Plains.

PSEUDOPOLYMORPHINA Cushman and Ozawa 1928

(**P. hanzawai*). Test elongate, usually somewhat compressed; early chambers quinqueloculine, later ones becoming biserial, slightly overlapping. **U. Cret.–Recent.**

P. rutila (Cushman) (7—3). **L. Olig.–Mioc.:** Fla., Miss.

SIGMOMORPHINA Cushman and Ozawa 1928

(**S. yokoyamai*). Test compressed, in adult at least, with chambers added in planes slightly less than 180° and more than 144° from one another, each succeeding chamber farther removed from the base. **Cret.–Recent.**

S. frondicula riformis Galloway and Wissler (7—4). **Plioc., Pleist.:** Cal.

POLYMORPHINA Orbigny 1826

(**P. burdigalensis*). Test usually broad and compressed; early chambers arranged in a sigmoid series, becoming biserial or entirely biserial from the start; the sigmoid character usually seen slightly throughout the biserial test. **Tert.–Recent.**

P. charlottensis Cushman (7—5). **Plioc.:** Cal.

BULLOPORA Quenstedt 1856

(**B. rostrata*). Test attached, consisting of a series of inflated chambers in a generally linear series, the chambers usually connected by definite tubular necks; wall calcareous, finely perforate, vitreous; aperture rounded, at end of tubular neck. **Jura.–L. Eoc.**

B. laevis (Sollas) (7—6). **U. Cret.:** N. J., Tex.; Alta.

NONION Montfort 1808

(**Nautilus incrassatus* Fichtel and Moll). Test free, planispiral, more or less involute, bilaterally symmetrical, periphery broadly rounded to acute; chambers numerous; wall finely or coarsely perforate, calcareous; aperture median, an arched, usually low opening between base of apertural face and preceding coil. **Jura.–Recent.**

N. advenum Cushman (7—7). **U. Eoc., L. Olig.:** Coastal Plain of U. S. A.

NONIONELLA Cushman 1926

(**N. miocenica*). Test free, subtrochoid, dorsal side only partly involute, ventral side completely so, close coiled; chambers in adult inequilateral, ventral side developing a distinct elongate lobe at the umbilical end, covering the umbilicus; wall calcareous, finely perforate; aperture at base of apertural face, low and elongate, extending from periphery toward ventral side. **Cret.–Recent.**

***N. miocenica** Cushman (7—8). **Mioc.:** Cal.

ELPHIDIUM Montfort 1808

(**Nautilus macellus* Fichtel and Moll). Test planispiral, bilaterally symmetrical, mostly involute; chambers numerous, with distinct sutures, either depressed, or raised and limbate, with septal bridges ("retral processes"); wall calcareous, perforate; apertures one or more at base of apertural face. **Eoc.–Recent.**

E. discoidale (Orbigny) (7—9). **Olig.–Pleist.:** Gulf Coastal Plain.

ELPHIDIELLA Cushman 1936

(**Polystomella arctica* Parker and Jones). Test differing from *Elphidium* in having two rows of openings at the sutures, and with a thickened area between the rows, without definite retral processes. **Plioc.–Recent.**

E. hannai (Cushman and Grant) (7—15). **Plioc.** or **Pleist.:** Alaska.

CAMERINA Bruguière 1792

(**C. laevigata*). Test lenticular, planispiral, typically bilaterally symmetrical, involute; wall perforate, calcareous, with a secondary skeleton and complicated canal system; aperture simple, at base of apertural face, median. **Carb.?–Olig.**

C. matleyi Vaughan (7—10–12). **M. Eoc.:** Jamaica.

OPERCULINA Orbigny 1826

(**Lenticulites complanata* Defrance). Test bilaterally symmetrical, planispiral, complanate, usually all coils visible from exterior, earlier coils sometimes involute, chambers undivided, periphery with a thickened "marginal cord"; wall calcareous, perforate, smooth or ornamented with bosses; aperture single, at base of apertural face, median. **L. Cret.–Recent.**

O. ocalana Cushman, var. (7—13). **Eoc.:** Fla.

HETEROSTEGINA Orbigny 1826

(**H. depressa*). Test in general similar to *Operculina*; early chambers simple, later ones divided into chamberlets; aperture a row of rounded openings on the narrow apertural face. **Eoc.–Recent.**

H. ocalana Cushman (7—14). **Eoc.:** Fla.

GÜMBELINA Egger 1899

(**Textularia globulosa* Ehrenberg). Test with early chambers planispiral, at least in the microspheric form, later chambers biserial; wall calcareous, perforate; aperture large and open, arched, at base of inner margin of last-formed chamber. **Cret.–Olig.**

***G. globulosa** (Ehrenberg) (8—1). **U. Cret.:** Tenn., Ala., Miss., Ark., Tex.

GÜMBELITRIA Cushman 1933

(**G. cretacea*). Test similar to *Gümbelina*, but triserial, wall calcareous, finely perforate; aperture large, at inner edge of last-formed chamber. **U. Cret.**

***G. cretacea** Cushman (8—2). **U. Cret.:** Ala., Miss., Tex.

RECTOGÜMBELINA Cushman 1932

(**R. cretacea*). Test with early portion similar to *Gümbelina*; later chambers uniserial, rectilinear, subglobular; wall calcareous, thin, very finely perforate; aperture in young like *Gümbelina*, in adult terminal, rounded, with a distinct neck. **U. Cret.**

***R. cretacea** Cushman (8—3). **U. Cret.:** Ark.

VENTILABRELLA Cushman 1928

(**V. eggeri*). Test in the early stages as in *Gümbelina*, in the adult with chambers alternating and spreading out fan-shaped in a single plane; wall calcareous, finely or coarsely perforate; aperture in biserial stage single, in adult chambers one aperture at each side near base of median line. **U. Cret.**

***V. eggeri** Cushman (8—4, 5). **U. Cret.:** Ala., Miss., Tex.

BOLIVINOIDES Cushman 1927

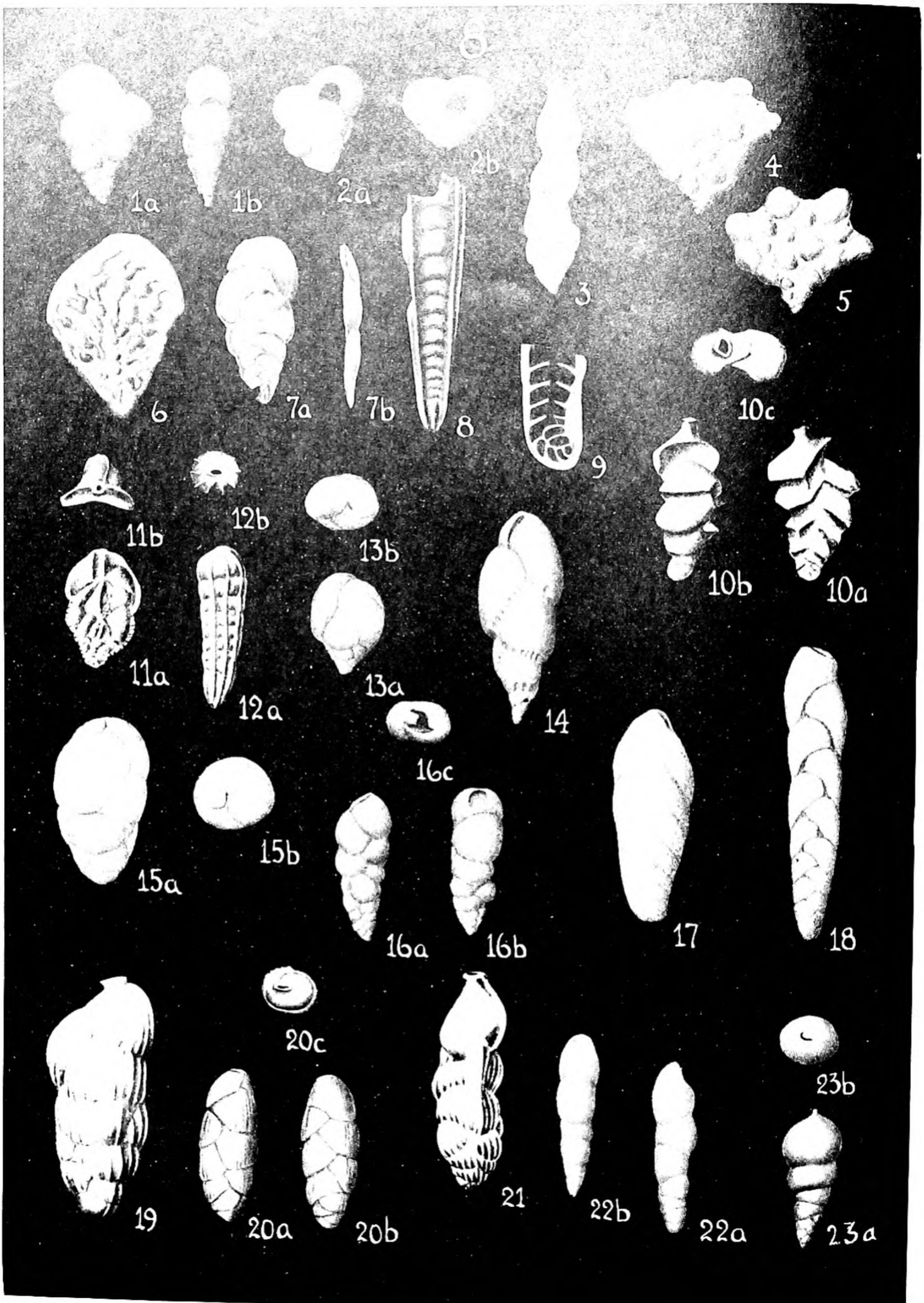
(**Bolivina draco* Marsson). Test compressed, rhomboid, thickest portion near apertural end, usually appearing like a thickened lip without ornamentation, which is in general at right angles to the sutures; earliest stage in microspheric form planispiral, quickly biserial; wall calcareous, finely perforate; aperture fairly large, at the inner margin. **U. Cret.**

B. decorata (Jones) (8—6). **U. Cret.:** Tenn., Ala., Miss., Ark., Tex.

BOLIVINITA Cushman 1927

(**Textularia quadrilatera* Schwager). Test with chambers biserial, periphery and broader sides all concave with strongly developed angles giving a quadrate end view to test; wall calcareous, perforate; aperture large, at base of inner margin in median line. **U. Cret.–Recent.**

B. planata Cushman (8—7). **U. Cret.:** Tenn., Tex.


1a
1b
2a
2b
3
4
5
6
7a
7b
8
9
10c
10b
10a
11b
12b
13b
11a
12a
13a
14
15b
15a
16c
16a
16b
17
18
20c
19
20a
20b
21
22b
22a
23b
23a

PLECTOFRONDICULARIA Liebus 1903

(**P. concava*). Test elongate, compressed microspheric form planispiral, then biserial, then uniserial, rectilinear, much compressed; wall calcareous, finely perforate; aperture in adult terminal, elliptical. **Eoc.–Recent.**

P. californica Cushman and Stewart (8—8, 9). **Plioc.:** Cal.

EOUVIGERINA Cushman 1926

(**E. americana*). Test elongate, the early chambers, at least in microspheric form, planispiral, later ones biserial, final ones irregularly triserial; wall calcareous, perforate; aperture circular or rhomboid, with a definite neck and usually a phialine lip. **U. Cret.**

***E. americana** Cushman (8—10). **U. Cret.:** Tenn., Tex.

PSEUDOUVIGERINA Cushman 1927

(**Uvigerina cristata* Marsson). Test in early stages of microspheric form biserial, later triserial; adult chambers triangular in section, with outer angle usually truncated; wall calcareous, usually coarsely perforate; aperture terminal, usually with a tubular neck and phialine lip. **U. Cret.–Eoc.**

P. plummerae Cushman (8—11). **U. Cret.:** Tenn., Miss., Ark., Tex.

SIPHOGENERINOIDES Cushman 1927

(**Siphogenerina plummeri*). Test elongate, slightly tapering, early stages biserial, later uniserial; wall calcareous, perforate, usually with longitudinal costae; aperture with a neck and phialine lip. **U. Cret.**

***S. plummeri** Cushman (8—12). **U. Cret.:** Tenn., Ala., Miss., Ark., Tex.

BULIMINELLA Cushman 1911

(**B. elegantissima* Orbigny). Test an elongate close spiral, the spiral suture distinct; chambers three or usually more in a whorl; wall calcareous, perforate; aperture elongate, loop-shaped, very slightly twisted. **Cret.–Recent.**

B. carseyae Plummer (8—13). **U. Cret.:** Ala., Miss., Ark., Tex.

BULIMINA Orbigny 1826

(**B. marginata*). Test an elongate spiral, generally triserial; chambers inflated, spiral suture more or less obsolete; wall calcareous, perforate; aperture loop-shaped, with a tooth or plate at one side and an internal spiral tube connecting through the chambers between the apertures. **Jura.–Recent.**

B. obtusa Orbigny (8—15). **U. Cret.:** Tex.

NEOBULIMINA Cushman and Wickenden 1928

(**N. canadensis*). Test in the early stages triserial as in *Bulimina*, adult biserial not compressed; chambers inflated, simple; wall calcareous, perforate; aperture in triserial stage as in *Bulimina*, in adult broader, tending to become subterminal. **Cret.**

***N. canadensis** C and W (8—16). **U. Cret.:** Tenn., Miss., Tex.; Alta.

ENTOSOLENIA Ehrenberg 1848

(**E. lineata* Williamson). Test a single chamber with an internal tube, free at inner end; wall calcareous, finely perforate; aperture elliptical or circular. **Tert., Recent.**

E. crumenata Cushman (6—15). **Eoc., Olig.:** Atlantic and Gulf Coastal Plains.

VIRGULINA Orbigny 1826

(**V. squammosa*). Test elongate, more or less compressed, fusiform; early chambers spiral about the elongate axis, especially in the microspheric form, triserial, later becoming irregularly biserial, while test usually twisted; wall calcareous, finely perforate; aperture elongate, loop-shaded, with an apertural tooth or plate and internal spiral tube. **L. Cret.–Recent.**

V. (**Virgulinella**) **miocenica** Cushman and Ponton (8—14). **Mioc.:** Atlantic Coastal Plain.

BOLIVINA Orbigny 1839

(**B. plicata*). Test elongate, usually compressed, tapering, initial end and often whole test twisted; chambers typically biserial; wall calcareous, finely or coarsely perforate; aperture elongate, usually oblique, somewhat loop-shaped, often with a plate-like tooth connecting with an internal tube. **Cret.–Recent.**

B. incrassata Reuss (8—17). **U. Cret.:** Tenn., Ala., Ark., Tex.; Mexico; Trinidad.

LOXOSTOMA Ehrenberg 1854

(**Loxostomum subrostratum*). Test in early stages

PLATE 8

[Figures are after Cushman unless other authorship is indicated in brackets.]

1. Gümbelina globulosa (x120). 1a, 1b: side, peripheral views. **2. Gümbelitria cretacea** (x100). 2a, 2b: side, apertural views. **3. Rectogümbelina cretacea** (x145). **4, 5. Ventilabrella eggeri** (x50). **6. Bolivinoides decorata** (x50). **7. Bolivinita planata** (x50). 7a, 7b: side, peripheral views. **8, 9. Plectofrondicularia californica** [Cushman and Stewart]. 8: exterior, x35; 9: section of microspheric young, x50. **10. Eouvigerina americana** (x75). 10a, 10b, 10c: front, side, and apertural views. **11. Pseudouvigerina plummerae** (x65). 11a, 11b: side, apertural views. **12. Siphogenerinoides plummeri** (x40). 12a, 12b: side, apertural views. **13. Buliminella carseyae** (x50). 13a, 13b: side, apertural views. **14. Virgulina (Virgulinella) miocenica** (x50) [Cushman and Ponton]. **15. Bulimina obtusa** (x50). 15a, 15b: side, apertural views. **16. Neobulimina canadensis** (x150). 16a, 16b, 16c: side views, apertural view. **17. Bolivina incrassata** (x70). **18. Loxostoma plaitum** (x70). **19. Uvigerina cookei** (x55). **20. Hopkinsina danvillensis** (x55) [Howe and Wallace]. 20a, 20b, 20c: side views, apertural view. **21. Angulogerina byramensis** (x75). **22. Pleurostomella subnodosa** (x35). 22a, 22b: side views. **23. Nodosarella coalingensis** (x30) [Cushman and Church]. 23a, 23b: front, apertural views.

1b 1c 1a 2a 2c 2b

3a 3c 3b 4a 4c 4b

5b 5c 5a

6a 6b

7a 7c 7b

8b 8a

9b 9c 9a

similar to *Bolivina*, adult tending to become uniserial; aperture terminal. **Cret.–Recent.**

L. plaitum (Carsey) (8—18). **U. Cret.:** Ala., Miss., Ark., Tex.

UVIGERINA Orbigny 1826

(**U. pigmea*). Test generally triserial, elongate, fusiform, rounded in transverse section; chambers inflated, rounded; wall calcareous, perforate; aperture terminal, rounded, with neck and lip, often with a spiral tooth and internal twisted tube. **Eoc.–Recent.**

U. cookei Cushman (8—19). **U. Eoc.:** N. C., S. C., Ga., Ala.

HOPKINSINA Howe and Wallace 1933

(**H. danvillensis*). Test in early stages similar to *Uvigerina*, in adult becoming biserial but somewhat twisted; wall calcareous, perforate; aperture terminal, oval or circular, usually with a short neck and lip. **Eoc.–Recent.**

***H. danvillensis** H and W (8—20). **Eoc.:** La.

ANGULOGERINA Cushman 1927

(**Uvigerina angulosa* Williamson). Test triserial, elongate, whole test angled, with three flattened sides and distinct angles, later chambers often loosely arranged; wall calcareous, perforate; aperture terminal, with a short neck and lip. **Eoc.–Recent.**

A. byramensis (Cushman) (8—21). **L. Olig.:** Coastal Plain of U. S. A.

PLEUROSTOMELLA Reuss 1860

(**P. subnodosa*). Test usually elongate, biserial; wall calcareous, perforate; aperture an arched opening on inner side of chamber, partly closed by two broad teeth at each side at base with a narrow vertical slit between. **Cret.–Recent.**

***P. subnodosa** Reuss (8—22). **U. Cret.:** Tex.

NODOSARELLA Rzehak 1895

(**Lingulina tuberosa* Gümbel). Test elongate, with early chambers showing traces of biserial ancestry, but later ones in a rectilinear series, very slightly involute; wall calcareous, perforate; aperture narrow, subterminal, semielliptical. **Cret.–Tert.**

N. coalingensis Cushman and Church (8—23). **U. Cret.:** Cal.

SPIRILLINA Ehrenberg 1843

(**S. vivipara*). Test typically free, occasionally attached, planispiral, composed of a subglobular or ovoid proloculum and a long, undivided, tubular, second chamber, close coiled, usually in one plane; wall calcareous, finely or coarsely perforate; aperture formed by open end of tube. **Camb.–Recent.**

S. vicksburgensis Cushman (9—6). **L. Olig.:** Miss.

PATELLINA Williamson 1858

(**P. corrugata*). Test conical or plano-convex, early whorls undivided, microspheric specimens sometimes entirely undivided, later ones usually divided into long chambers, often with internal sinuous septa partly dividing the chamber; wall calcareous, perforate, thin; aperture elongate, at base of ventral side of chamber. **Perm.–Recent.**

P. advena Cushman (9—8). **L. Olig.–Mioc.:** Gulf Coastal Plain.

DISCORBIS Lamarck 1804

(**D. vesicularis*). Test typically plano-convex, the ventral side flattened, microspheric form sometimes showing a long, close-coiled second chamber of several coils before division; chambers often produced to partly cover umbilical area; wall calcareous, perforate; aperture at base of umbilical margin on ventral side of chamber. **Jura.–Recent.**

D. subaraucana Cushman (9—1). **Eoc.–Plioc.:** Fla., Ala., Mexico.

LAMARCKINA Berthelin 1881

(**Pulvinulina erinacea* Karrer). Test trochoid, evidently attached, dorsal side convex, usually ornamented, ventral side usually flattened or concave, very smooth and highly polished; chambers dorsally distinct, ventrally less so, but often with an umbilical projection; wall calcareous, finely perforate; aperture at umbilical end of chamber, often enlarged by resorption. **U. Cret.–Recent.**

L. ripleyensis Cushman (9—2). **U. Cret.:** Tenn., Miss.

VALVULINERIA Cushman 1926

(**V. californica*). Test usually trochoid, close coiled, ventrally umbilicate; chambers numerous; wall calcareous, finely perforate; aperture ventral, large, extending from umbilicus toward periphery, often with a thin plate filling the umbilical area, sometimes extending into face of chamber, becoming tripartite. **Cret.–Recent.**

V. casitasensis Cushman and Laiming (9—3). **Mioc.:** Cal.

GYROIDINA Orbigny 1826

(**G. orbicularis*). Test trochoid, ventral side usually convex, umbilicus small and deep, spiral suture with a depressed channel; wall calcareous, finely per-

PLATE 9

[Figures are after Cushman unless other authorship is indicated in brackets; C and M = Cushman and McGlamery.]

1. Discorbis subaraucana (x120) [C and M]. 1a, 1b, 1c: dorsal, ventral, and side views. **2. Lamarckina ripleyensis** (x90). **3. Valvulineria casitasensis** (x33) [Cushman and Laiming]. **4. Gyroidina girardana** (x40). **5. Stensiöina excolata** (x60) [Cushman and Dorsey]. **6. Spirillina vicksburgensis** (x100). **7. Eponides alabamensis** (x120) [C and M]. **8. Patellina advena** (x120) [Cushman and Cahill]. **9. Rotalia byramensis** (x120) [C and M].

1

2

3b

3a

4c

4b

4a

5a

5b

5c

6a

6c

6b

7b

7a

8b

8c

8a

9c

9b

9a

10a

10c

10b

11

12a

12b

13b

13a

forate; aperture a low arched opening on ventral side toward umbilical area. **L. Cret.–Recent.**

G. girardana (Reuss) (9—4). **U. Cret.:** Tenn., Ala., Miss., Ark., Tex.

STENSIÖINA Brotzen 1936

(**Rotalia exsculpta* Reuss). Test trochoid, planoconvex, dorsal side flattened, ventral side convex, umbilicate, all chambers visible from dorsal side, only those of last-formed whorl from ventral side; chambers distinct, simple; sutures dorsally raised and ornate, ventrally simple and depressed; wall calcareous, perforate, often coarsely so on ventral side; aperture an elongate slit at base of last-formed chamber on ventral side. **Cret.**

S. excolata (Cushman) (9—5). **U. Cret.:** Mexico.

EPONIDES Montfort 1808

(**Nautilus repandus* Fichtel and Moll). Test trochoid, usually biconvex, umbilical area closed but not typically with a plug; wall calcareous, perforate; aperture a low opening between periphery and umbilical area, usually well away from peripheral margin. **Jura.–Recent.**

E. alabamensis Cushman and McGlamery (9—7). **Olig.:** Ala.

COLEITES Plummer 1934

(**Pulvinulina reticulosa*). Test trochoid in young, uncoiling and broad in adult; chambers in a single series; wall calcareous, coarsely perforate; aperture in young ventral, in adult subterminal, elliptical, with a slight tooth on ventral side. **Midway** and **Wilcox Eoc.**

***C. reticulosus** (Plummer) (10—1, 2). **Eoc.:** Ala., Tex.

ROTALIA Lamarck 1804

(**R. trochidiformis*). Test trochoid, usually biconvex, umbilical area closed, usually with a conical plug of clear shell material; sutures usually limbate dorsally, usually deeply depressed ventrally, often ornamented along the sides; wall calcareous, perforate, often double, with a canal system; aperture on ventral side between periphery and umbilical area. **Cret.–Recent.**

R. byramensis Cushman (9—9). **Olig.:** Ala., Miss.

SIPHONINA Reuss 1850

(**S. fimbriata*). Test trochoid, biconvex, umbilical region typically closed; wall calcareous, coarsely perforate; aperture elliptical, just ventral to periphery, its long axis parallel to it, in fully developed species with a short neck and phialine lip. **Cret.–Recent.**

S. howei Cushman (10—3). **Eoc.:** Ala.

SIPHONINELLA Cushman 1927

(**Truncatulina soluta* Brady). Test in early stages similar to *Siphonina*, later becoming uncoiled; wall calcareous, perforate; aperture in adult terminal, elliptical, with a neck and lip. **Eoc.–Recent.**

S. claibornensis Cushman and Howe (10—4). **Eoc.:** La.

CANCRIS Montfort 1808

(**Nautilus auriculus* var. β Fichtel and Moll). Test trochoid, nearly equally biconvex, compressed; chambers few, rapidly enlarging; wall calcareous, perforate, umbilical area with a clear plate of rather large dimensions for size of test; aperture narrow, on inner border of ventral side of last-formed chamber. **Tert., Recent.**

C. sagra (Orbigny) (10—8). **Olig.–Pleist.:** Cuba; Gulf Coastal Plain of U. S. A.; Mexico; Cal.

ASTERIGERINA Orbigny 1839

(**A. carinata*). Test trochoid, biconvex, ventral side usually more strongly so than dorsal; chambers on dorsal side regularly coiled, ventrally with angular supplementary chambers between the regular series, large regularly rhomboid, dorsal sutures simply curved; wall calcareous, finely perforate; aperture ventral, at base of chamber margin. **Eoc.–Recent.**

A. subacuta Cushman (10—5). **Olig.:** Ala., Miss.

CERATOBULIMINA Toula 1915

(**Rotalina contraria* Reuss). Test rotaliform; dorsally all chambers visible, ventrally only those of the last-formed whorl, close coiled, ventrally umbilicate; wall calcareous, finely perforate, added to as growth progresses, laminate, entire exterior polished; aperture elongate, extending into ventral side of chamber; in perfect adult specimens, aperture covered by a thin convex plate, merged into chamber wall above aperture in a semi-circular line, lower end thin, liplike. **U. Cret.–Recent.**

C. cretacea Cushman and Harris (10—6). **U. Cret.:** Tenn., Miss., Ark., Tex.

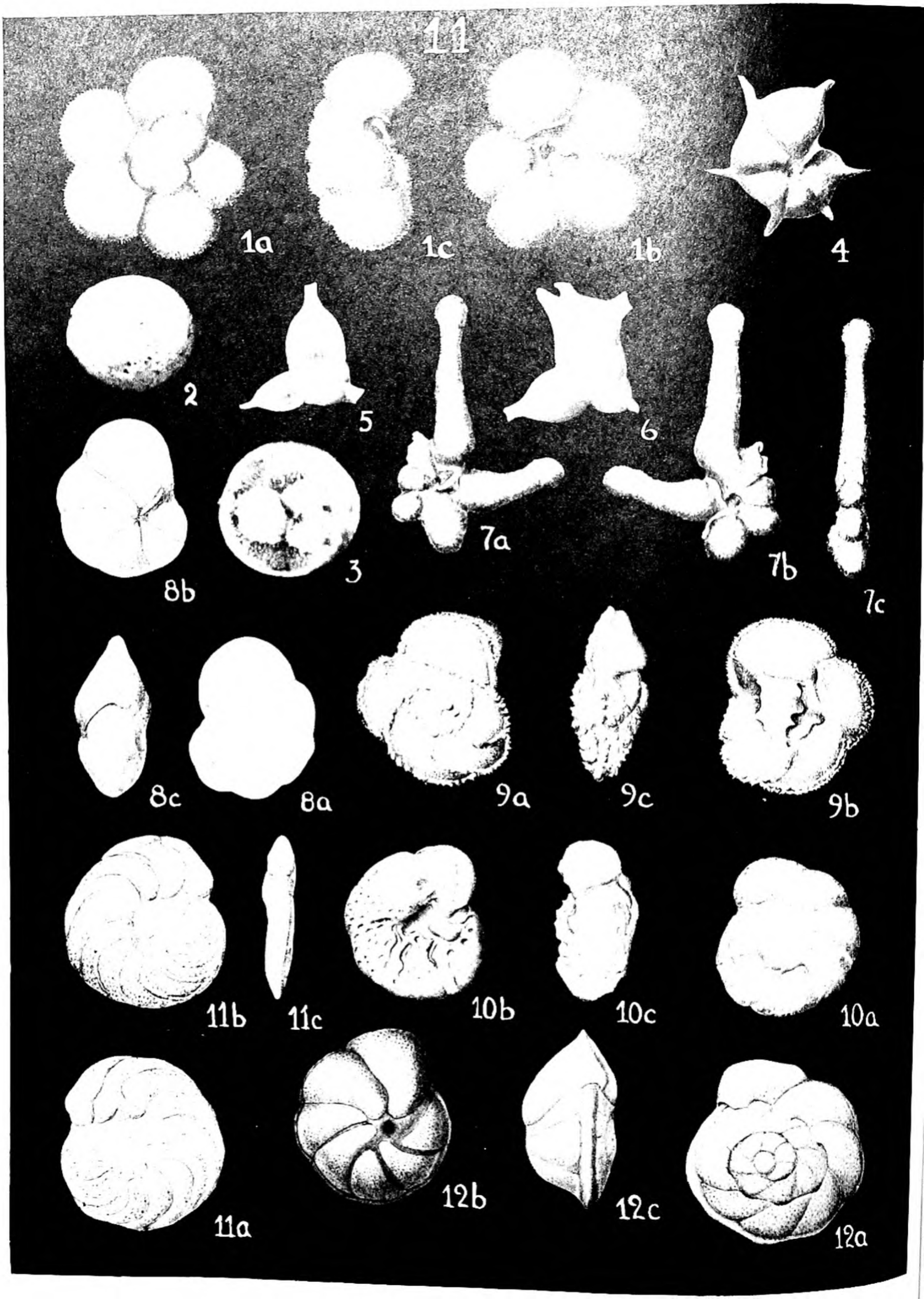
PULVINULINELLA Cushman 1926

(**P. subperuviana*). Test trochoid, close coiled; all

PLATE 10

[Figures are after Cushman unless other authorship is indicated in brackets.]

1, 2. Coleites reticulosus (x45) [Cushman and Garrett]. **3. Siphonina howei** (x65). 3a, 3b: dorsal, ventral views. **4. Siphoninella claibornensis** (x65) [Cushman and Howe]. 4a, 4b, 4c: dorsal, ventral, and apertural views. **5. Asterigerina subacuta** (x90) [Cushman and McGlamery]. 5a, 5b, 5c: dorsal, ventral, and side views. **6. Ceratobulimina cretacea** (x65) [Cushman and Harris]. 6a, 6b, 6c: dorsal, ventral, and apertural views. **7. Ehrenbergina spinosissima** (x50) [Cushman and Jarvis]. 7a, 7b: front, apertural views. **8. Cancris sagra** (x50). 8a, 8b, 8c: dorsal, ventral, and side views. **9. Cassidulina cretacea** (x90). 9a, 9b, 9c: opposite sides, apertural view. **10. Pulvinulinella texana** (x90). 10a, 10b, 10c: dorsal, ventral, and side views. **11. Gypsina rubra** (x50). **12. Allomorphina velascoensis** (x85). 12a, 12b: dorsal, side views. **13. Pullenia salisburyi** (x100) [Stewart and Stewart]. 13a, 13b: side, apertural views.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chambers visible dorsally, only those of the last-formed coil from the ventral side, very slightly if at all umbilicate; sutures on dorsal side oblique, ventrally nearly radial; wall calcareous, perforate; aperture on ventral side of peripheral face, elongate, somewhat loop-shaped, nearly parallel to plane of coiling, sometimes with a slight toothlike projection on one side. **Cret.–Recent.**

P. texana (10—10). **U. Cret.:** Ark., Tex.

CASSIDULINA Orbigny 1826

(**C. laevigata*). Test close coiled, lenticular or subglobular, usually involute; chambers alternating on both sides of periphery, usually smooth, sometimes highly ornate; wall calcareous, perforate; aperture elongate, close to peripheral plane, often with a platelike tooth. **U. Cret.–Recent.**

C. cretacea Cushman (10—9). **U. Cret.:** Tenn.

EHRENBERGINA Reuss 1850

(**E. serrata*). Test with microspheric young compressed, planispiral; adult test compressed at right angles to that of early coiling and becoming uncoiled, developing a dorsal side which is flattened or slightly convex, and a ventral which is thickest near median line; wall calcareous, perforate; aperture elongate, on ventral side near periphery. **Eoc.–Recent.**

E. spinosissima Cushman and Jarvis (10—7). **Mioc.:** Jamaica.

ALLOMORPHINA Reuss 1850

(**A. trigona*). Test trochoid, adult with usually three chambers to a coil; chambers inflated and enlarging rapidly as added, often very involute; wall calcareous, perforate; aperture an elongate arched opening, below border of last-formed chamber on ventral side, sometimes with a slight lip. **U. Cret.–Recent.**

A. velascoensis Cushman (10—12). **U. Cret.:** Mexico.

PULLENIA Parker and Jones 1862

(**Nonionina sphaeroides* Orbigny). Test in adult planispiral, close coiled; chambers completely involute, a few making up the coil; wall calcareous, perforate; aperture an elongate crescentic opening at inner margin of last-formed chamber. **Cret.–Recent.**

P. salisburyi Stewart and Stewart (10—13). **Plioc.:** Cal.

GLOBIGERINA Orbigny 1826

(**G. bulloides*). Test trochoid throughout, umbilicate; chambers in young, especially of the microspheric form, in a flattened trochoid form like *Discorbis*, usually smooth and with thin wall, later chambers globular; wall calcareous, thick and cancellated; in well-preserved specimens, especially pelagic ones, clothed with long slender spines coming from angles of cancellated surface areas, the base of such areas with pores of the wall; aperture large, opening into umbilicus. **Cret.–Recent.**

G. cretacea Orbigny (11—1). **U. Cret.:** Widely distributed in N. America and elsewhere.

HASTIGERINELLA Cushman 1927

(**Hastigerina digitata* Rhumbler). Test with early chambers trochoid, later ones planispiral, involute, in the young; in adult, chambers are elongate, club-shaped, the spines being limited to outer ends of chambers. **U. Cret.–Recent.**

H. watersi Cushman (11—7). **U. Cret.:** Tex.

CANDORBULINA Jedlitschka 1933

(**C. universa*). Test trochoid in early stages with small apertures along sutures, later developing a final chamber entirely enveloping the earlier ones, with apertures in a circle. **Mioc.**

***C. universa** Jedlitschka (11—2, 3). **Mioc.:** Md., Fla.; Panama; Cal.

SCHACKOINA Thalmann 1932

(**Siderolina cenomana* Schacko). Test in earliest stages slightly trochoid, later nearly planispiral and involute; chambers with a single, peripheral, tubular spine in young, or several in adult; wall calcareous, finely perforate; aperture a low arch, at chamber base. **U. Cret.**

S. multispinata (Cushman and Wickenden) (11—5, 6). **U. Cret.:** Man.; Tex.

HANTKENINA Cushman 1924

(**H. alabamensis*). Test planispiral throughout, close coiled; chambers distinct, usually involute, each with an acicular spine at anterior angle or becoming obsolete in adult; wall calcareous, perforate; aperture median, at base of chamber, typically arched with a basal lobe at each side. **M.** and **U. Eoc., L. Olig.?.**

***H. alabamensis** Cushman (11—4). **Eoc.:** Ga., Ala., Miss.

PLATE 11

[Figures are after Cushman unless other authorship is indicated in brackets.]

1. Globigerina cretacea (x90). 1a, 1b, 1c: dorsal, ventral, and side views. **2, 3. Candorbulina universa** (x45) [Cushman and Dorsey]. 2: exterior with rings of small apertures and early globigerine chambers showing from exterior; 3: showing early globigerine chambers. **4. Hantkenina alabamensis** (x40). **5, 6. Schackoina multispinata** [Cushman and Wickenden]. 5: young, x200; 6: adult, x120. **7. Hastigerinella watersi** (x60). 7a, 7b, 7c: opposite sides; peripheral view. **8. Globorotalia fohsi** (x65) [Cushman and Ellisor]. 8a, 8b, 8c: dorsal, ventral, and side views. **9. Globotruncana cretacea** (x90). 9a, 9b, 9c: dorsal, ventral, and side views. **10. Anomalina rubignosa** (x38) [Cushman and Jarvis]. 10a, 10b, 10c: dorsal, ventral, and side views. **11. Planulina harangensis** (x40) [Cushman and Ellisor]. 11a, 11b, 11c: dorsal, ventral, and side views. **12. Cibicides martinezensis** (x75) [Cushman and Barksdale]. 12a, 12b, 12c: dorsal, ventral, and side views.

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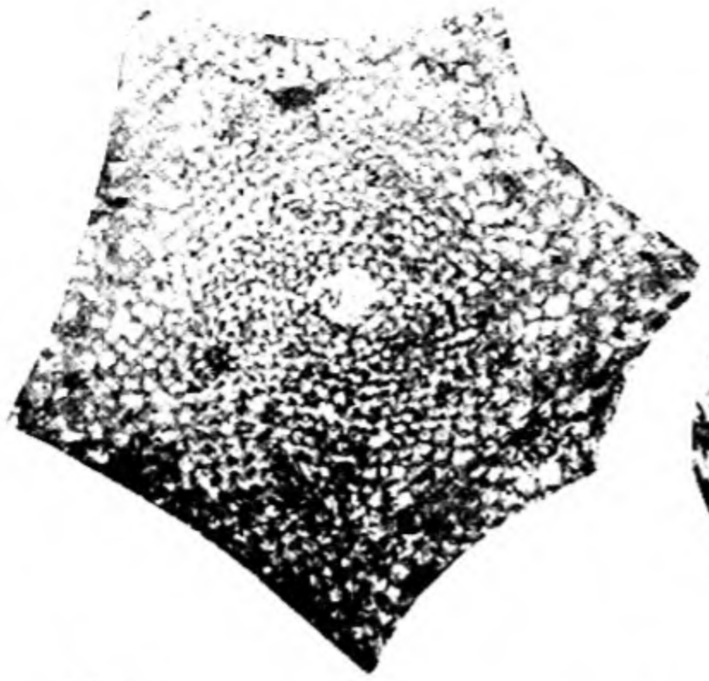

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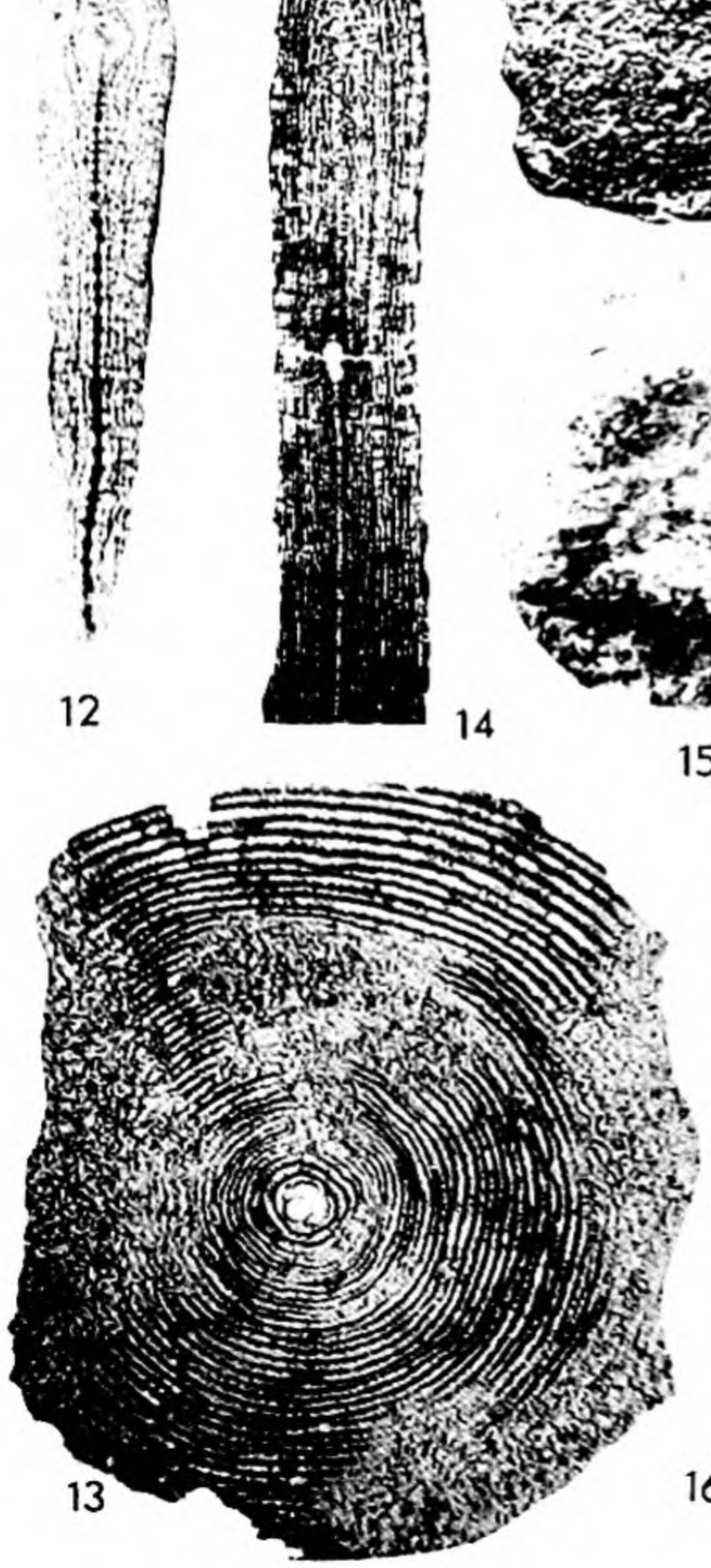

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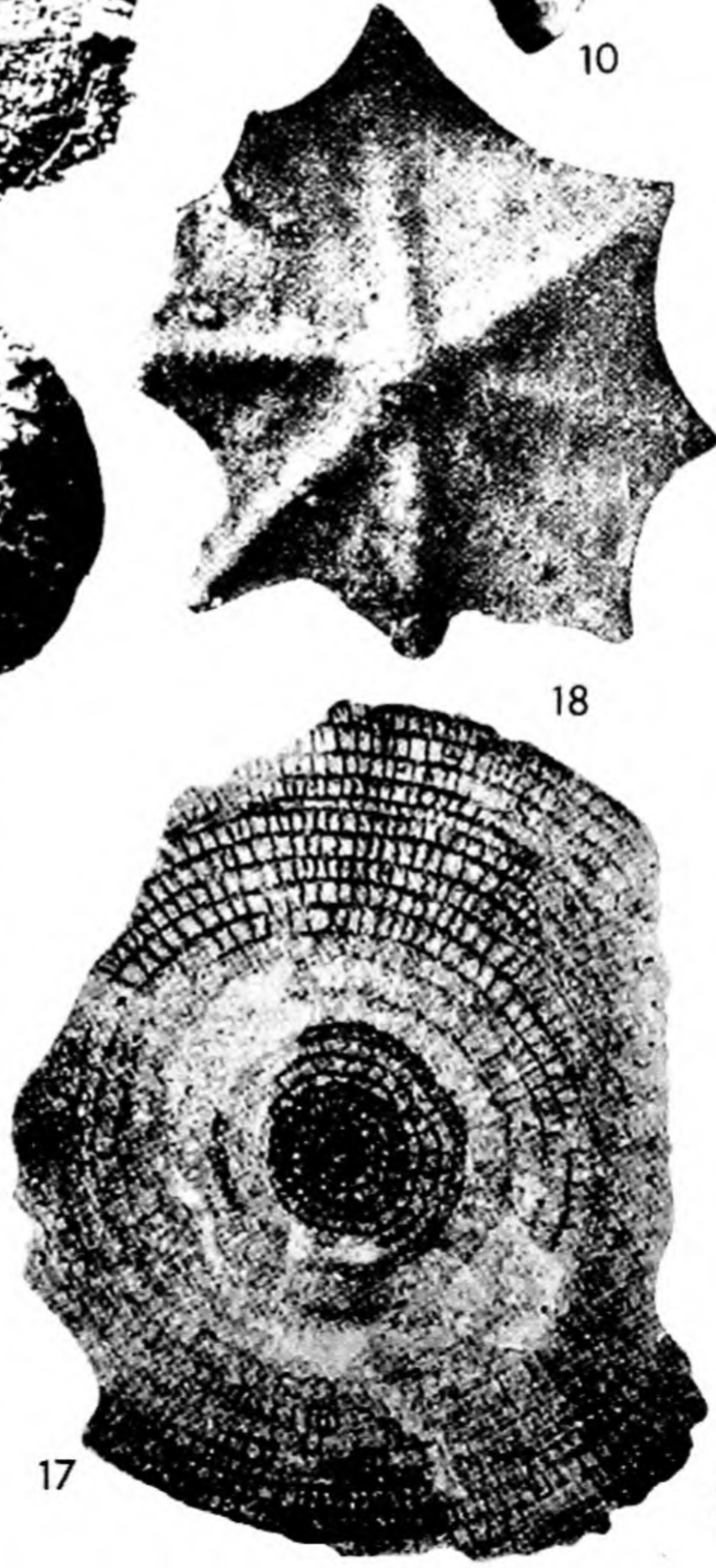

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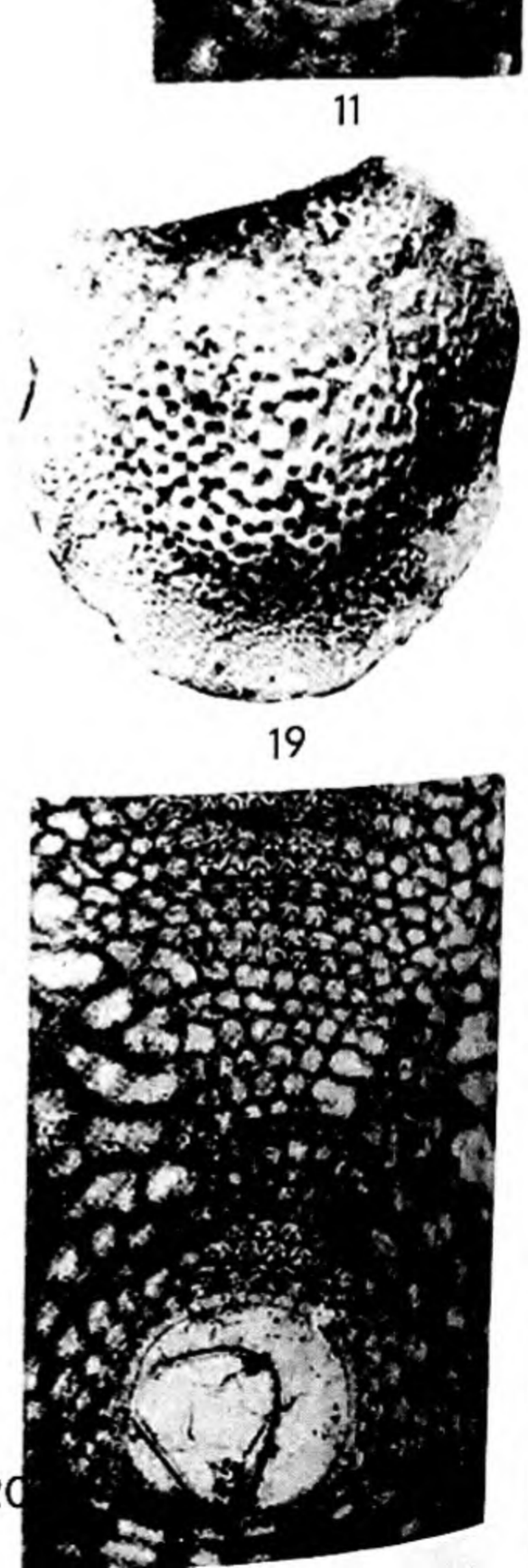

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GLOBOTRUNCANA Cushman 1927

(**Pulvinulina arca*). Test trochoid in young; chambers usually globose, rough, and cancellated, adult usually much compressed; dorsal and ventral side either flat or convex, ventral side sometimes slightly concave; periphery truncate, usually with a double keel on dorsal and ventral sides; aperture ventral, in well-preserved specimens with a thin platelike structure over umbilical area; apparently pelagic in part. **U. Cret.**

G. cretacea Cushman (**11**—9). **U. Cret.:** Tenn., Ala., Miss., Ark., Tex.

GLOBOROTALIA Cushman 1927

(**Pulvinulina menardii tumida* Brady). Test trochoid; earliest chambers often like *Globigerina*, with a rough cancellated exterior, biconvex, dorsal side more or less flattened, ventral side strongly convex; wall calcareous, perforate, frequently spinose in whole or in restricted areas; aperture large, opening into umbilicus, which is either open or partly covered by a lip. **U. Cret.–Recent.**

G. fohsi Cushman and Ellisor (**11**—8). **Mioc.**. La.

ANOMALINA Orbigny 1826

(**A. punctulata*). Test in young trochoid, adult often nearly involute dorsally as well as ventrally; chambers added nearly in a planispiral manner, the inner coils of dorsal side often appearing as a central raised boss; wall calcareous, perforate; aperture in young ventral, in adult becoming peripheral, at base of last-formed chamber in median line, sometime with a boss of clear material over umbilical region **L. Cret.–Recent.**

A. rubignosa Cushman (**11**—10). **U. Cret.:** Trinidad; Mexico.

PLANULINA Orbigny 1826

(**P. ariminensis*). Test in young trochoid, adult much compressed, evolute; earlier chambers visible from both sides in megalospheric form, microspheric form with central area raised on dorsal side; wall calcareous, coarsely perforate; aperture at base of chamber at median line. **Cret.–Recent.**

P. harangensis Cushman and Ellisor (**11**—11). **Mioc.:** La.

CIBICIDES Montfort 1808

(**C. refulgens*). Test plano-convex, trochoid, usually attached by flattened dorsal side; wall calcareous, coarsely perforate; aperture peripheral, at base of chamber, sometimes extending ventrally, but typically with a long slitlike extension dorsally between inner margin of chamber and previous whorl, nearly length of chamber. **Cret.–Recent.**

C. martinezensis Cushman and Barksdale (**11**—12). **Eoc.:** Cal.

CYPSINA Carter 1877

(**Orbitolina vesicularis* Parker and Jones). Test a generally spherical mass of compressed chambers, sometimes arranged in more or less radial rows; early stages attached, on a small object completely covering it and forming a spherical mass, but becoming free early and becoming spherical; apertures formed by coarse pores of wall. **Cret.?–Recent.**

G. rubra (Orbigny) (**10**—11). **Olig.:** Gulf Coastal Plain.

ORBITOIDAL FORAMINIFERA

Prepared by W. Storrs Cole

PSEUDOLEPIDINA Barker and Grimsdale 1937

(**P. trimera*). Test small, asymmetrical lenticular; papillate; nucleoconch composed of two subequal chambers, partly embraced by a third chamber lying above equatorial plane on less convex side; equatorial chambers irregular arcuate in form and variable in size; equatorial zone double except at center of test; lateral chambers arranged in layers rather than tiers; equatorial zone not sharply differentiated from lateral chambers: pillars present. **Eoc.** (Mex.).

***P. trimera** B and G (**12**—3, 4). **M. Eoc.:** Veracruz, Mex.

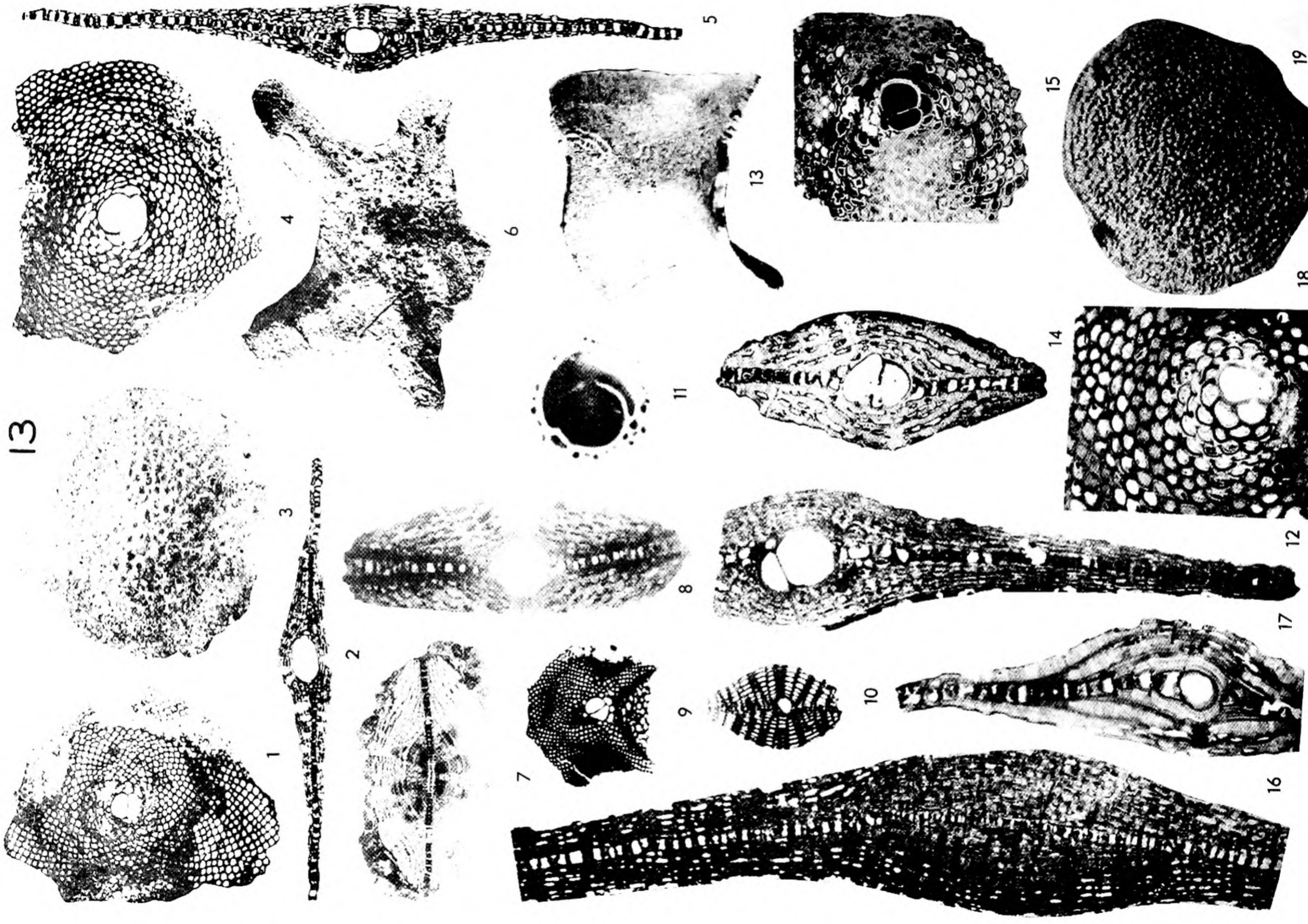
ORBITOIDES Orbigny 1847

(**O. media* Archiac). Test lenticular, compressed, surface ornamented with vermicular pillars or radiating costae; embryonic chambers enveloped in a thick shell, at first quadrilocular, occasionally later bilocular, by atrophy and fusion of three initial chambers, producing larger chamber embracing a smaller; equatorial chambers with curved outer wall and inwardly converging lateral walls, radial shorter than transverse diameter; communication between chambers by a few round lateral apertures. **U. Cret.** (West Indies; Europe; India).

PLATE 12

[Figures are after Vaughan unless other authorship is indicated in brackets; V and C — Vaughan and Cole.]

1, 2. Lepidorbitoides (Asterorbis) rooki (x25) [V and C]. 1: vertical section; 2: horizontal section passing through embryonic and equatorial chambers of a pentagonal specimen. **3, 4. Pseudolepidina trimera** [Barker and Grimsdale]. Vertical (x24) and equatorial (x20) sections. **5, 6. Pseudorbitoides israelskii** (x25) [V and C]. Vertical section, and horizontal section showing embryonic chambers. **7, 8. Orbitoides palmeri** [Gravell]. Vertical section (x28) and enlarged view (x74) of embryonic and equatorial chambers. **9. Pseudophragmina (Proporecyclina) flintensis** (x6) [Cushman]. External view. **10. Discocyclina (Asterocyclina) georgiana** (x6). Exterior. **11. Lepidorbitoides minima** (x17). Embryonic and equatorial chambers. **12, 13. Pseudophragmina (Athecocyclina) cookei.** Vertical (x27.8) and equatorial (x15) sections. **14, 15. Discocyclina (Discocyclina) advena.** Vertical section (x15) and exterior (x5). [14, Gravell and Hanna; 15, Cushman.] **16, 17. Pseudophragmina (Proporecyclina) perpusilla** (x40). Vertical section, and embryonic and equatorial chambers. **18. Discocyclina (Asterocyclina) mariannensis** (x4) [Cushman]. Exterior. **19, 20. Lepidocyclina (Eulepidina) favosa.** Exterior (x5), and portion of equatorial section (x16) showing embryonic and equatorial chambers.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O. palmeri Gravell (12—7, 8). Test small, biconical, one side more rounded than other; small pillars present. **U. Cret.:** Cuba.

PSEUDORBITOIDES Douvillé 1922

(**P. trechmanni* Douvillé). Test lenticular, compressed or robust, small, papillate; embryonic chambers in microspheric specimens a distinct spiral, in megalospheric forms a large subspherical initial chamber connected through an aperture with a slightly smaller chamber, following these two or more smaller chambers, the entire group forming an irregular spiral; equatorial chambers irregular polygonal or hexagonal, forming radiating rows, communication by stoloniferous apertures, a single layer in central part of test, two or even three layers near periphery, radiating lines present above chambers; lateral chambers in definite tiers with open relatively large cavities. **U. Cret.** (La., Tex.; Jamaica; Cuba; Guatemala).

P. israelskii Vaughan and Cole (12—5, 6). Small, thick, lenticular, sometimes nearly globular. **U. Cret.:** La., Tex.; Cuba; Guatemala.

LEPIDORBITOIDES Silvestri 1907

(**Orbitolites socialis* Laymerie). Test small to medium, flat to inflated, lenticular, circular (*Lepidorbitoides*); or stellate, with or without raised ridges (*Asterorbis*); papillate; nucleoconch bilocular, first chamber subspherical, second somewhat larger, slightly reniform, partly embracing initial ones, in some specimens a series of chambers slightly larger than equatorial chambers partly embracing embryonic chambers, in others one such chamber, or none; equatorial chambers with curved outer walls and truncate or pointed inner ends, occasionally spatuliform or hexagonal; communication between equatorial chambers by six stoloniferous apertures; roofs and floors of equatorial chambers and roofs of lateral chambers cribriform perforate; pillars present. **U. Cret.** (Fla., Miss., La.; Cuba; eastern Mex.; **Maestrichtian** of Europe and India).

L. (Lepidorbitoides) minima Douvillé (12—11). **U. Cret.:** Cuba; eastern Mex.

L. (Asterorbis) rooki Vaughan and Cole (12—1, 2). **U. Cret.:** Miss.; Cuba.

LEPIDOCYCLINA Gümbel 1870

(**Nummulites mantelli* Morton). Test flat to inflated, lenticular, circular, selliform or stellate; surface glabrous or papillate, with or without costae or radial ridges; embryonic chambers of various types—(*a*) several large chambers, as many as 10, two or more subequal in size (*Polylepidina*); (*b*) two equal or unequal chambers, separated by a straight wall (*Lepidocyclina ss*); (*c*) two unequal embryonic chambers, larger partly embracing smaller (*Nephrolepidina*); (*d*) two unequal chambers with larger completely surrounding smaller except at point of attachment (*Eulepidina*) — equatorial chambers in plan arcuate, rhomboid, diamond-shaped, elongate or short spatulate, elongate or short hexagonal with intergradation between several types in single individuals; pillars and papillae or pustules variable in development. **L. Eoc.–L. Mioc.** (worldwide in tropical and near-tropical latitudes in shallow-water sediments). (See Schenck, H. G., and Childs, T. S., Jr., Significance of *Lepidocyclina* (*Lepidocyclina*) *californica*, new species, in the Vaqueros formation (Tertiary), California: *Stanford Univ. Pub.*, g s 3 (2): 1–59, pl 1–4, 1942.)

L. (Polylepidina) gardnerae Cole (13—17, 18). Lateral chambers very irregularly developed with thick roofs and floors. **Eoc.** (Claiborne [Cook Mountain]): Fla. to E. Tex.

L. (Lepidocyclina) claibornensis Gravell and Hanna (13—14, 15). Equatorial chambers arcuate in plan view; lateral chambers not arranged in regular tiers with thick roofs and floors; large, cone-shaped pillars present. **Eoc.** (Claiborne [Cook Mountain]): About 55 feet above *L. (Polylepidina) gardnerae* zone, Fla. to La.

L. (Lepidocyclina) mortoni Cushman (13—1–3). Equatorial chambers arcuate in plan; lateral chambers not arranged in regular tiers with thin roofs and floors; pillars irregular in size and distribution. **U. Eoc.** (Jackson [Moody's Branch], Ocala): Fla. to Tex.; Cuba.

L. (Nephrolepidina) fragilis Cushman (13—11, 12). **U. Eoc.:** Fla. (Ocala).

***L. (Lepidocyclina) mantelli** (Morton) (13—16). Equatorial chambers hexagonal in plan; lateral chambers low and long; pillars absent in typical form. **Olig.** (Marianna): Fla. to Miss.

L. (Lepidocyclina) parvula Cushman (13—7, 8). Equatorial chambers hexagonal in plan; lateral chambers arranged in regular tiers between pillars; pillars extremely variable in size; surface papillae variable, depending on development of pillars. **M. Olig.:** Fla.; Antigua; Jamaica; Trinidad; eastern Mexico (Meson).

PLATE 13

[Figures are after Gravell and Hanna unless other authorship is indicated in brackets.]

1–3. Lepidocyclina (Lepidocyclina) mortoni (x11.9). Equatorial and vertical sections, and exterior. **4, 5. L. (Lepidocyclina) supera** (x17.8). Equatorial and vertical sections. **6. L. (Lepidocyclina) texana.** Exterior, x10. **7, 8. L. (Lepidocyclina) parvula** [Cole]. Vertical section (x13.5) of a microspheric specimen, and the same (x36.5) of a megalospheric form. **9, 10. L. (Lepidocyclina) yurnagunensis** (x15) [Cole]. Equatorial section showing embryonic apparatus and diamond-shaped equatorial chambers, and vertical section. **11, 12. L. (Nephrolepidina) fragilis** (x20) [Vaughan]. Embryonic chambers, and vertical section. **13. L. (Eulepidina) undosa.** Exterior, x4.3. **14, 15. L. (Lepidocyclina) claibornensis** (x26). Vertical and equatorial sections. **16. L. (Lepidocyclina) mantelli** (x18.3) [Vaughan]. Portion of vertical section of microspheric specimen. **17, 18. L. (Polylepidina) gardnerae** (x36.5) [Cole]. Vertical section, and portion of equatorial section. **19. Pseudophragmina (Pseudophragmina) floridana** (= **Orthophragmina floridana* Cushman) [Vaughan]. Exterior, x6.

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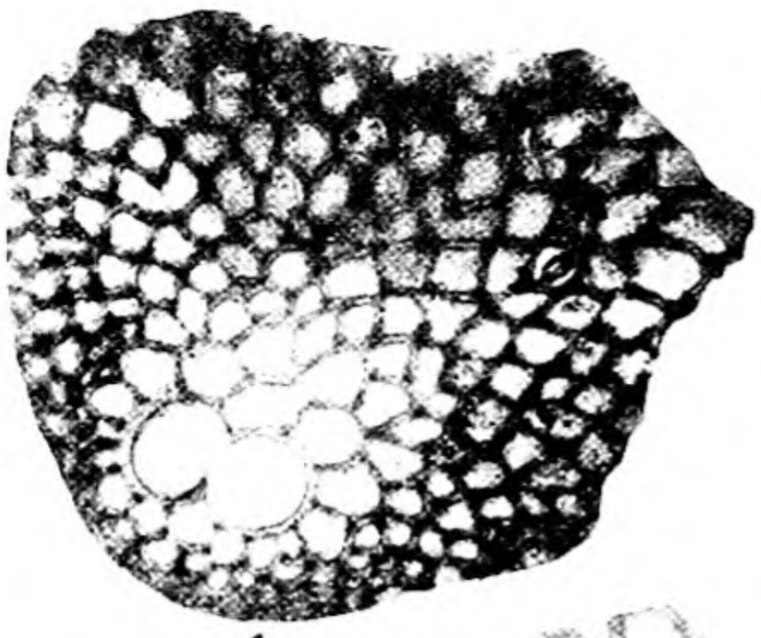

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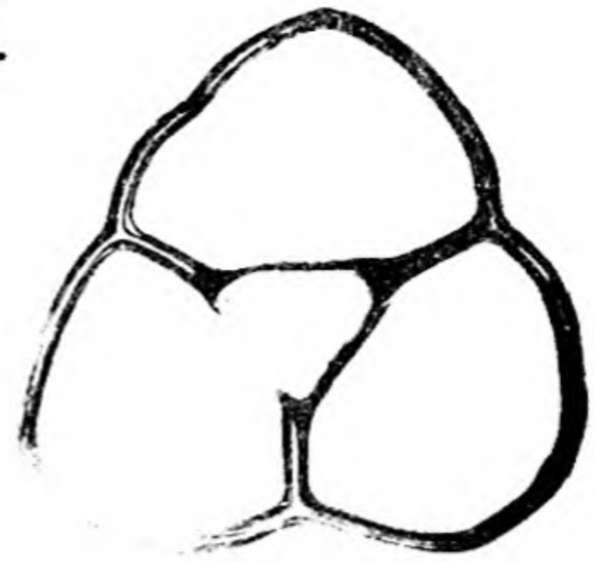

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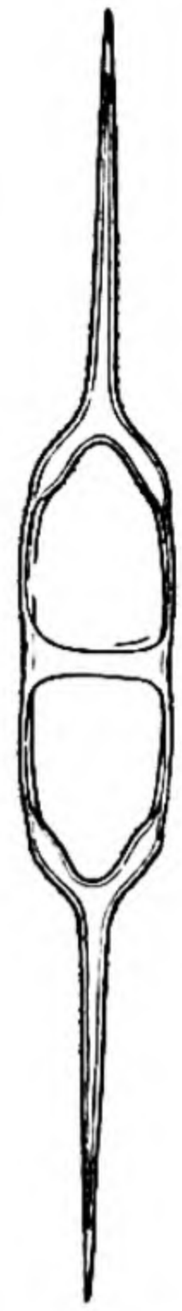

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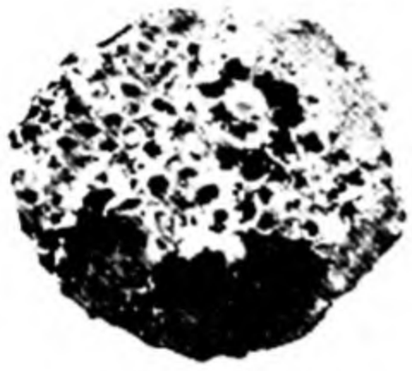

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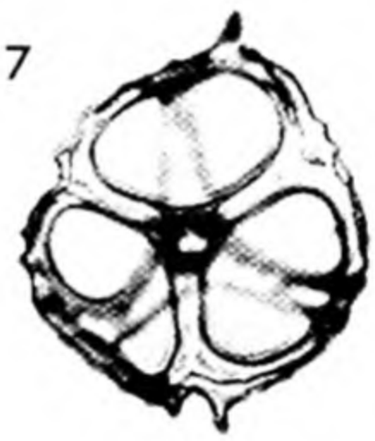

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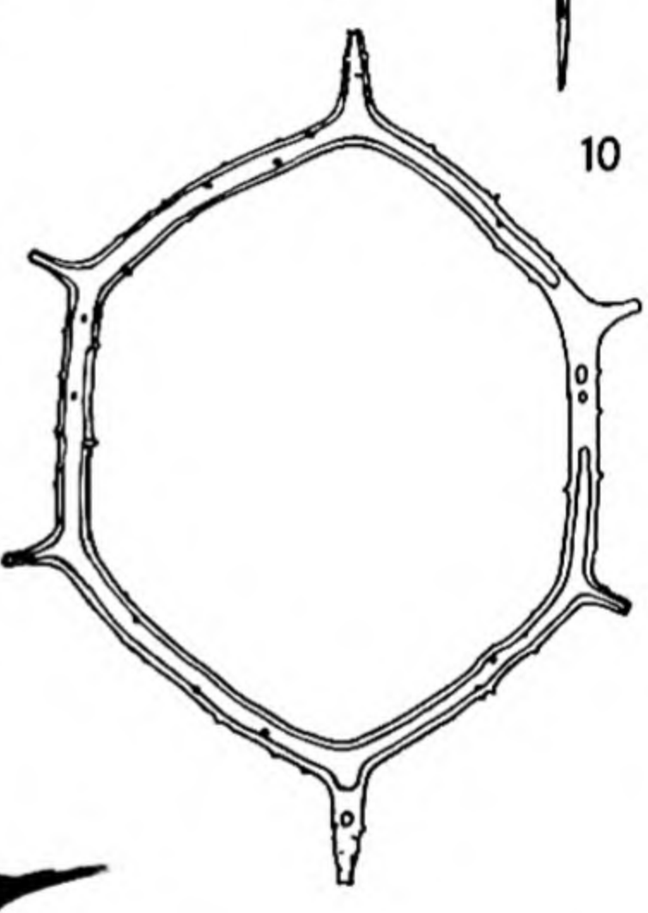

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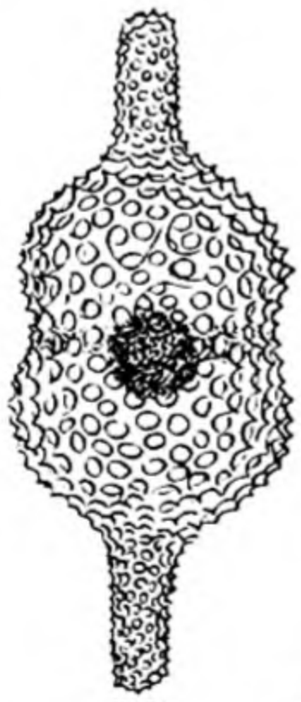

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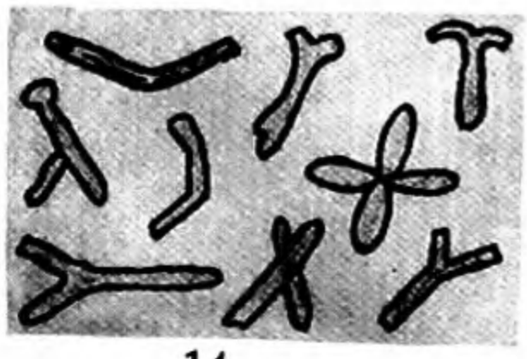

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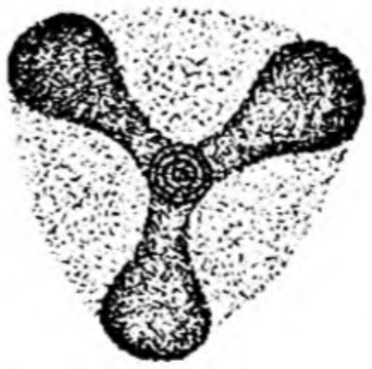

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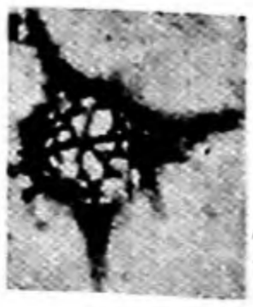

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L. (Lepidocyclina) yurnagunensis Cushman (**13**—9, 10). Equatorial chambers diamond- or lozenge-shaped, arranged in regular tiers; pillars absent or weakly developed in typical form; pillars well developed in var. *morganopsis* Vaughan; ending in large surface pustules. **Olig.:** Fla. (Suwannee); Antigua (Antigua); Jamaica (Moneague); Cuba; Haiti; Cayman Brac, Cayman Islands; Trinidad.

L. (Lepidocyclina) supera (Conrad) (**13**—4, 5). Equatorial chambers hexagonal in plan; lateral chambers low, decidedly irregular in shape and size, with floors and walls varying greatly in thickness; pillars well developed. **Olig.:** Fla. (Suwannee), Ala. (Byram), Miss. (Byram); Mexico (Alazan).

L. (Eulepidina) undosa Cushman (**13**—13). **M,** and **U. Olig.:** Fla. (Suwannee), Ga. (Flint River). Miss. (Byram, Chickasawhay); Antigua (Antigua); Cayman Brac, Cayman Islands; Jamaica (Moneague); Haiti; Venezuela (San Luis); Mexico (Meson).

L. (Eulepidina) favosa Cushman (**12**—19, 20). **M.** and **U. Olig.:** Fla. (Suwannee), Miss. (Byram, Chickasawhay); Antigua; Haiti; Venezuela; Mexico.

L. (Lepidocyclina) texana Gravell and Hanna (**13**—6). Test stellate, five-rayed. **Olig.** (*L. texana* horizon of Heterostegina zone): La., Tex.

DISCOCYCLINA Gümbel 1870

(**Orbitulites pratti* Michelin). Test discoidal, lenticular, thin or inflated, selliform (*Discocyclina ss*), or with elevated rays without protuberant angles on margin of test (*Aktinocyclina*), or radiate with 4 to more than 12 rays projecting beyond margin of test (*Asterocyclina*); surface granulate; embryonic chambers bilocular, small, subglobular chamber, partly embraced by larger chamber; equatorial chambers rectangular, usually radially elongate, arranged in more or less concentric rings; chambers in same ring communicate by annular stolons, situated at proximal end of radial wall; lateral chambers greatly developed, composing most of test normally; pillars usually well developed, terminating on surface in papillae or granulations of distinctive specific character. **Danian** to uppermost **Eoc.** (North, Central, and South America; West Indies; Europe; India; New Zealand; Tonga Islands; East Indies.)

D. (Discocyclina) advena (Cushman) (**12**—14, 15). Test with thinner central area with thicker surrounding part which thins peripherally; surface without distinct papillae. **M. Eoc.** (Cane River): Ala. to Tex.

D. (Aktinocyclina) bainbridgensis Vaughan. Test thin, discoidal, with 6 or 7 narrow, flat-topped, subequal costae, with slightly less prominent intervening costae radiating toward periphery, but becoming obsolete near margin of test. **U. Eoc.:** Ga. (Ocala).

D. (Asterocyclina) georgiana (Cushman) (**12**—10). Test quadrangular, interradial areas flat between four arms. **U. Eoc.:** U. Ocala of Fla., Ga., Ala., Miss.; Jamaica; Panama; Nicaragua (Brito); Venezuela.

D. (Asterocyclina) mariannensis (Cushman) (**12**—18). Test flattened, conspicuously stellate with 8 to 11 raised ribs, running to peripheral angles. **U. Eoc.** (U. Ocala): Fla., Ga.

PSEUDOPHRAGMINA Douvillé 1923

(**Orthophragmina floridana* Cushman [**13**—19]). Test circular in plan, discoidal, lenticular, thin or inflated, occasionally undulate; embryonic chambers as in *Discocyclina*; equatorial chambers with radial walls degenerate, often represented by rows of granules (*Pseudophragmina ss*), with radial walls complete (*Proporocyclina*), with radial walls absent or indistinct (*Athecocyclina*); annular stolons connecting equatorial chambers in distal side of equatorial chambers; lateral chambers present. **Eoc.** (N. America).

P. (Athecocyclina) cookei (Vaughan) (**12**—12, 13). Test thin, undulate, flattish or selliform; surface minutely granulate. **L. Eoc.** (Wilcox [Salt Mountain]): Fla., Ala., Tex.

P. (Proporocyclina) perpusilla (Vaughan) (**12**—16, 17). Test very thin, waferlike; surface with very minute papillae. **M. Eoc.:** Tex.: Guayabal of Tampico Embayment, Mexico.

P. (Proporocyclina) flintensis (Cushman) (**12**—9). Test compressed, thin, with a distinct central boss; surface slightly pustulate. **U. Eoc.:** Ocala of Fla. and Ga.; Haiti; Venezuela (Menegrande, Poloma Alta).

MIOGYPSINA Sacco 1893

(**Nummulites globulina* Michelotti). Test compressed, small, trigonal or suborbicular in plan; sur-

PLATE 14

Figures are after Hanna [JP 1; AAPG, B 12; etc.] unless other authorship or place of publication is indicated in brackets; Md G S = Md Geol Surv, Miocene Volume.]

1–4. Miogypsina spp. [photographs furnished by W. S. Cole]. **1, 2. M. (Miogypsina) hawkinsi** (x36.5). Equatorial and vertical sections. **3, 4. M. (Miogypsinopsis) gunteri** (x36.5). Vertical and equatorial sections. **5. M. (Miolepidocyclina) panamensis** (x20) [Vaughan]. Equatorial section showing bilocular embryonic chambers situated some distance from periphery. **6. Corbisema geometrica** (x525). **7, 8. Lyramula furcula** (x375). **9, 10. Naviculopsis biapiculata** (approximately x700) [Frenguelli]. **11, 12. Rhabdoliths** and **coccoliths** from the Cretaceous of Manitoba (x1250) [Can Nat 7]. **13, 14. Coccoliths** and **rhabdoliths** from the Cretaceous of Minnesota, probably x1250 [Minn G S 3 (1)]. **15. Dictyocha fibula** (x650). **16. Ebria antiqua** (x700). **17. Vallacerta hortoni** (x600). **18. Mesocena elliptica** (approximately x700) [Frenguelli]. **19. Distephanus ornamentatus** (x750). **20. Cannartiscus amphicylindricus** (x195) [Md G S]. **21. Anthocyrtium doronicum** (x240) [Md G S]. **22. Dictyocoryne profunda** (x90) [Md G S]. **23. Porodiscus concentricus** (x162) [Md G S]. **24. Hexalonche microsphaera** (x131) [Md G S]. **25. Cannartidium** sp. (x112) [Md G S]. **26. Cenosphaera porosissima** (x131) [Md G S]. **27. Hexastylus basiporosus** (x93) [JP 14]. **28. Acanthosphaera dodecaspinosa** (x93) [JP 14]. **29. Carposphaera equalis** (x93) [JP 14].

face papillate; embryonic apparatus excentric in position, in some forms apical or subapical, composed of two equal or subequal chambers, followed by several chambers of slightly different character than normal equatorial chambers (*Miogypsina ss*), or followed by several subquadrate chambers arranged in a trochoid spiral (*Miogypsinopsis*); in other forms, embryonic apparatus like *Miogypsina ss*, but separated from periphery of test by several annules of equatorial chambers (*Miolepidocyclina*); spiral and interseptal canals are present; equatorial chambers rhomboid or elongate hexagonal with net of canals in chamber walls; lateral chambers well developed; pillars present, terminating in surface papillae. **Olig.–Plioc.** (N. America; Europe; East Indies).

M. (**Miogypsina**) **hawkinsi** Hodson (**14**—1, 2). **M.** and **U. Olig.:** Fla.; Trinidad; Venezuela.

M. (**Miogypsinopsis**) **gunteri** Cole (**14**—3, 4). **Olig.:** Fla., Miss.; Tampico Embayment, Mexico.

M. (**Miolepidocyclina**) **panamensis** (Cushman) (**14**—5). **Olig.:** Panama.

Order Radiolaria.[1] Marine protozoans which secrete a perforated chitinous membrane, and usually also an outer skeleton of siliceous lattice-work or isolated spicules; the siliceous skeletons are extremely fragile and are usually too much broken for accurate identification; in exceptional cases, however, they are exceedingly numerous and well preserved (e.g. in the Devonian Caballos chert of Texas and the Miocene of Barbados); skeletons may be expected in sedimentary rocks from the **Pre-Cambrian** to **Recent.**

Fossil radiolarians have been reported, and some have been described and illustrated, from numerous formations distributed widely over North America. These occurrences are in the following:

Ordovician Deepkill-Normanskill cherts of New York (Ruedemann and Wilson 1935), and from cherts of Notre Dame Bay, Newfoundland (Sampson 1923).

U. Devonian cherts of California (Diller 1913), novaculite and Big Fork chert of Arkansas (Henbest 1936), and Caballos chert of Texas (Aberdeen 1940).

Permian Leonard and Wood formations of Marathon Basin of Texas (King 1930).

Jurassic cherts of the Kenai Peninsula (Martin *et al.* 1912) and of Oregon (Smith 1916) and Franciscan cherts of California (Hinde 1894).

U. Cretaceous Milwood of Manitoba (Rüst 1892), and Mowry of Wyoming (Rubey 1929).

Eocene radiolarian earth of California (Clark and Campbell 1937) .

Miocene Calvert of Maryland (Martin 1904), and Barbados radiolarian earth (Ehrenberg 1875).

A few genera are illustrated on another page to show shape, size, and general structure of typical forms. More than 750 genera and 4,200 species of living radiolarians have been described. Only a very few of these have been reported as fossils.

Hexastylus basiporosus Aberdeen (**14**—27), **Acanthosphaera dodecaspinosa** Aberdeen (**14**—28), and **Carposphaera equalis** Aberdeen (**14**—29). **Dev.:** Tex. (Caballos).

Anthocyrtium doronicum Haeckel (**14**—21), **Cannartiscus amphicylindricus** Haeckel (**14**—20), **Cenosphaera porosissima** Vinassa (**14**—26), **Dictyocoryne profunda** Ehrenberg (**14**—22), **Hexalonche microsphaera** Vinassa (**14**—24), **Porodiscus concentricus** (Ehrenberg) (**14**—23), and **Cannartidium** sp. (**14**—25), all from **Mioc.** of Md.

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CHAPTER III

PHYLUM PORIFERA [1]

Multicellular animals, chiefly marine; body vase-like and fleshy with internal supporting skeleton or detached skeletal elements (*spicules*); fleshy wall penetrated by a complex series of canals through which water circulates from exterior to central cavity (*cloaca*, *paragaster*), whence it escapes through openings (*osculi*) on upper or outer surface; benthonic, sessile with basal attachment, and living at both shallow and bathyal depths.

Most modern sponges secrete a skeleton of horny fibers, which is frequently reinforced by siliceous or calcareous spicules of various forms (**16, 17**). Siliceous spicules have a tiny axial canal; calcareous ones are solid. In many extinct sponges these spicules were the most prominent hard parts and frequently became thickened and united to form a solid trellis or framework which retained the form of the sponge on fossilization. In some sponges this framework is regularly reticulated, in others it consists of very irregular branching spicules, and in still others it is apparently a felted mass of spicules. Some forms (e.g. *Dictyospongia*) apparently were delicate nets of siliceous fibers, judging from the shape and surface impression of the shale and sandstone internal fillings. Sponges usually are poorly preserved, difficult to determine accurately, and of little value as index fossils. The following classification is now in general use:

Class **Silicispongiae**
- Order **Monactinellida**
- Order **Tetractinellida**
- Order **Lithistida**
- Order **Hexactinellida**

Class **Calcispongiae**

Class **Pleospongia** (Archaeocyathids)

Incertae sedis

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[1] **Bassler, R. S.,** A new early Ordovician sponge fauna: *Wash Ac Sc*, J 17: 390–394, 1927; The Nevada Ordovician (Pogonip) sponge fauna: *USNM*, Pr 91: 91–102, pl 19–24, 1941. **Beecher, C. E.,** Brachiospongidae: *Peabody Mus (Yale)*, Mem 2 (1): 1–28, il, 1889. **Caster, K. E.,** Siliceous sponges from Mississippian and Devonian strata of the Penn-York embayment: *JP* 13: 1–20, 1939. **Clarke, J. M.,** A sphinctozoan Calcisponge from the Upper Carboniferous of eastern Nebraska: *Am G* 20: 387–392, 1897; Devonian glass sponges: *N Y St Mus*, B 196: 177–198, il, 1918; The great glass-sponge colonies of the Devonian: *JG* 28: 25–37, 1920. **Dawson, J. W.,** Fossil sponges from the Quebec group: *R Soc Can*, Pr Tr (2) 2 (4): 91–121, 1896. **Duncan, P. M.,** Spheroidal lithistid Spongida from Silurian of New Brunswick: *An Mag N H* (5) 4: 84–91, 1879. **Eller, E. R.,** Upper Devonian sponge collection acquired by the Carnegie Museum [*Abst*]: *GSA*, Pr 1934: 364, 1935; Upper Devonian sponges [New York and Pennsylvania]: *Science* (ns) 84: 41, 1936. **Fenton, C. L.** and **M. A.,** Boring sponges in the Devonian of Iowa: *Am Mid Nat* 13: 44–54, 1932; *Cliona* from Cretaceous of New Jersey: Idem: 54–62, 1932. **Girty, G. H.,** Sponges of Lower Helderberg group of New York: *N Y St Mus*, An Rp 48 (2): 259–322, il; *N Y St G*, An Rp 14: 259–322, il, 1897; Carboniferous fossils: *USNM*, Pr 34: 281–303, 1908. **Hall, J.,** and **Clarke, J. M.,** Dictyospongiae: *N Y St Mus*, Mem 2: 1–350, il, 1898. **Head, W. R.,** Catalogue of recognized Paleozoic sponges of North America, p 1–11, Chicago, 1895. **Hinde, G. J.,** *Hindia: An Mag N H* (5) 19: 67–79, 1887; Sponges from Quebec group and Utica slate: *Can Rec Sc* 3: 59–68, 1888; *Archaeocyathus* Billings: *GSL*, QJ 45: 125–148, 1889; British fossil sponges: *Palaeontogr Soc*, 1887–1893; Receptaculidae: *AJS* 29: 69, 1885. **Holl, H. B.,** Fossil sponges: *G Mag* 9: 309–315, 343–352, 1872; *Cin QJ Sc* 1: 65–80, 1874. **Howell, B. F.,** Two new sponges from Silurian of Tennessee: *Wag Free Inst Sc*, B 12: 31–35, 1937; "*Zittelella varians*" from Ordovician of Vermont: Idem, B 13: 31–35, 1938. **Howell, B. F.,** and **Landes, R. W.,** Monactinellid sponges from Ordovician of Wisconsin: *JP* 10: 53–59, 1936. **Howell, B. F.,** and **Van Houten, F. B.,** A new sponge from the Cambrian of Wyoming: *Wag Free Inst Sc*, B 15: 1–8, 1940. **James, J. F.,** Sponges: recent and fossil: *Am Nat* 29: 536–545, 1895. **King, R. H.,** Pennsylvanian sponge fauna from Texas: *U Tex B* 3201: 75–85, 1932; Pennsylvanian sponges of north-central Texas: *JP* 12: 498–504, 1938. **Merrill, J. A.,** Fossil sponges in Lower Cretaceous of Texas: *MCZ (Harvard)*, B 28: 1–26, 1895. **O'Connell, M.,** The Schrammen collection [foreign] of Cretaceous Silicispongiae in the American Museum of Natural History: *AMNH*, B 41: 1–261, 1919. **Okulitch, V. J.,** Cyathospongia; a new class of Porifera to include the Archaeocyathinae: *R Soc Can*, Tr 29 (4): 75–106, 1935; Changes in nomenclature of Archaeocyathi: *JP* 11: 251–252, 1937; *GSA*, Pr 1936: 358, 1937; Type Pleospongia from eastern Canada: *R Soc Can*, Tr 34: 75–87, il, 1940. **Rauff, H.,** Palaeospongiologie. *Palaeontogr*. 40: 1–346, 1893; 41: 223–272, 1895. **Raymond, P. E.,** Sponges of Chazy formation: *Vt G S*, Rp 3: 151–161, 1902; Systematic position of Archaeocyathinae: *MCZ (Harvard)*, B 55: 172–177, 1931. **Raymond, P. E.,** and **Okulitch, V. J.,** Chazyan sponges: Idem, B 86: 197–214, il, 1940. **Taylor, T. G.,** Archaeocyathinae: *R Soc S Australia*, Mem 2 (2): 1–188, il, 1910. **Thomas, A. O.,** Paleozoic glass sponges from Iowa: *Ia Ac Sc*, Pr 29: 85–90, 1924?; A fossil burrowing sponge from Iowa Devonian: *Ia Univ Lab N H*, B 6: 165–166, 1911. **Ulrich, E. O.,** Lower Silurian [Ordovician] sponges: *Am G* 3: 233–248, 1889; American Paleozoic sponges: *Ill G S* 8: 209–241, il, 1890; Sponges of the Devonian and Carboniferous systems: Idem: 243–251, il, 1890. **Ulrich, E. O.,** and **Everett, O.,** Lower Silurian [Ordovician] sponges: Idem: 253–282, il, 1890. **Walcott, C. D.,** Middle Cambrian Spongiae: *SMC* 67: 261–364, il, 1920. **Weller, J. M.,** Siliceous sponges of Pennsylvanian age from Illinois and Indiana: *JP* 4: 233–251, il, 1930. **Wells, J. W.,** A new Calcisponge from Buda limestone of Central Texas: *JP* 8: 167–168, 1934. **Winchell, N. H.,** and **Schuchert, C.,** Sponges from Lower Silurian [Ordovician] of Minnesota: *Minn G S* 3 (1): 55–95, il, 1895.

This reference list is long because no general work of recent date monographs the phylum. While the list obviously leaves the impression that fossil sponges are numerous, the reverse is really the case; yet, because fossil sponges are not uncommon, adequate reference material is considered justifiable.

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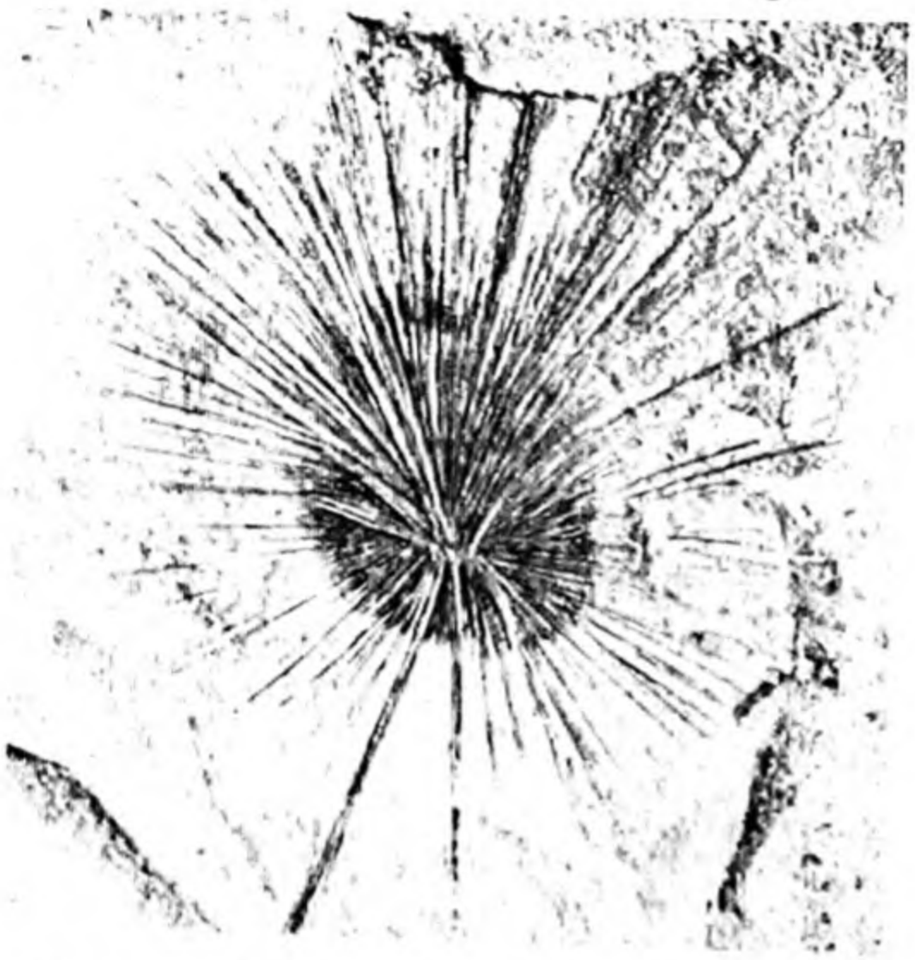

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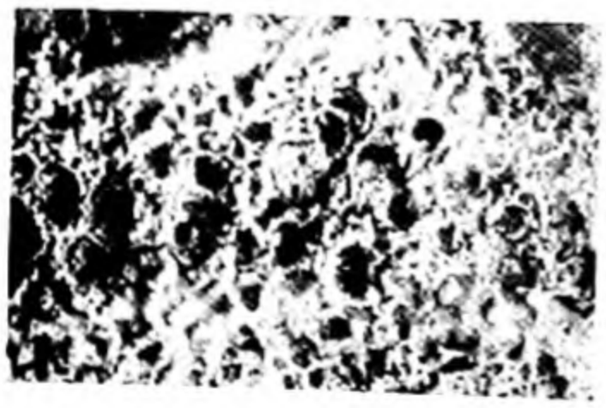

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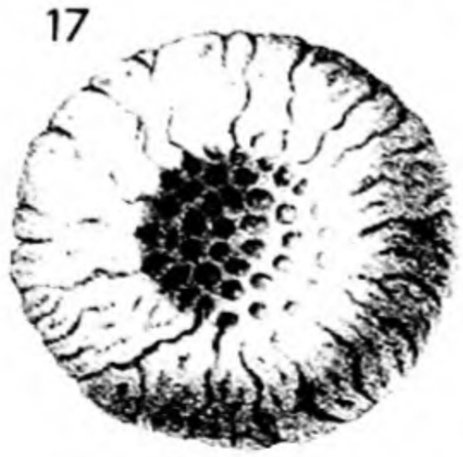

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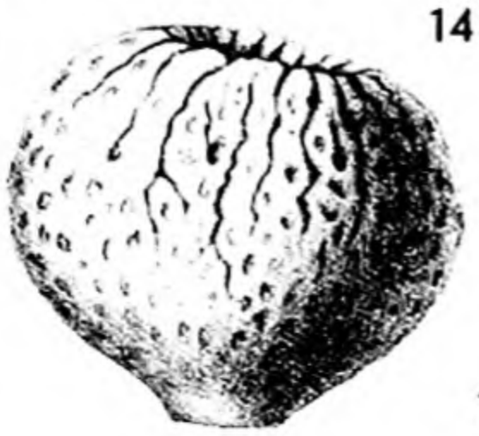

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CLASS SILICISPONGIAE

Order Monactinellida. Skeleton of anastomosing spongin fibers incasing many uniaxial siliceous spicules, which may be straight or curved, smooth or prickly, and sharpened or truncated and which always have an axial canal; group includes freshwater sponges and most existing marine forms. **Camb.–Recent.**

LEPTOMITUS Walcott 1886

(= TUPONIA Walcott 1920)

(**L. zitteli*). Elongate, cylindrical sponge, with skeleton formed of vertical spicules, with transverse extensions dividing the space between them, possibly in all species; entire sponge flexible. **Camb.**

***L. zitteli** Walcott. **L. Camb.:** Vt. (Parker), Pa. (Kinzers).

L. lineatus Walcott (**15**—1, 2). **M. Camb.:** B. C. (Burgess).

CHOIA Walcott 1920

(**C. carteri*). Free, covered by numerous spicules, many of which extend beyond margin of the slightly concave disk. **Camb.** (Que., B. C.; Utah; Wales).

***C. carteri** Walcott (**15**—7). Diameter of subcircular disk 10 to 20 mm; larger spicules extend 15 to 20 mm beyond margin. **M. Camb.** (Burgess): B. C.

PETROSITES Howell and Landes 1936

(**P. humilis*). "Form genus," including simple, smooth, straight or gently curved, diactinal siliceous sponge spicules; axial canal terminates within spicule. **L. Ord.** (An unnamed species has also been reported by Weller (1930) from the **L. Penn.** of southern Indiana and Illinois.)

***P. humilis** H and L (**15**—3). **L. Ord.:** Wis.

Order Tetractinellida. Skeleton composed of tetraxial spicules which usually are detached or bound by spongin, but which may also form rather rigid masses; detached spicules rare. **Ord.–Recent.**

ARCHAEOSCYPHIA Hinde 1889

(**Petraia minganensis* Billings). Vaselike or cylindrical, apparently free; outer surface with strongly marked annular projections; like *Archeocyathus*, but lacking inner wall. **Ord.** (Newf.; Que.)

***A. minganensis** (Billings) (**15**—5, 6). Large, with nodose exterior; inner space large; septa numerous. **Ord.:** Newf.; Mingan Islands, Que. (Romaine).

NEVADOCOELIA Bassler 1927

(**N. wistae*). Simple, erect, obconical, pedunculate sponges pierced throughout their length by a wide cloaca and marked on their outer surface by transverse ridges or rows of nodes. **Ord.**

***N. wistae** Bassler (**15**—16, 17). Sponge elongate cylindrical with surface marked by undulating, transverse parallel ridges and exhibiting pores about 0.35 mm wide opening in longitudinal rows; interior pierced by a cloaca one-third width of sponge. **Chazyan:** Nev. (U. Pogonip).

LISSOCOELIA Bassler 1927

(**L. ramosa*). Sponge consisting of smooth, cylindrical, hollow stems, branching at irregular intervals; surface minutely porous; cloaca narrow but extending full length of sponge. **Ord.**

***L. ramosa** Bassler (**15**—13). Sponge body of smooth, cylindrical, hollow, branching stems, with surface showing minute rounded pores penetrating spicular tissue and interior formed of a narrow cloaca extending its full length. **Chazyan:** Nev. (U. Pogonip).

Order Lithistida. Skeleton thick-walled; usually with complicated canal system; spicules irregular monaxons or tetraxons united to form a rigid skeleton capable of preservation in fossil state; most abundant of all fossil sponges. **Camb.–Recent.**

EOSPONGIA Billings 1861

(**E. roemeri*). Solitary, pyriform or club-shaped sponges with a shallow dorsal depression; sponge traversed by approximately vertical tubes which are irregularly arranged, and not separated by radial structures. **Ord.**

***E. roemeri** Billings (**15**—4). **Chazyan:** Mingan Islands, Que. (Mingan).

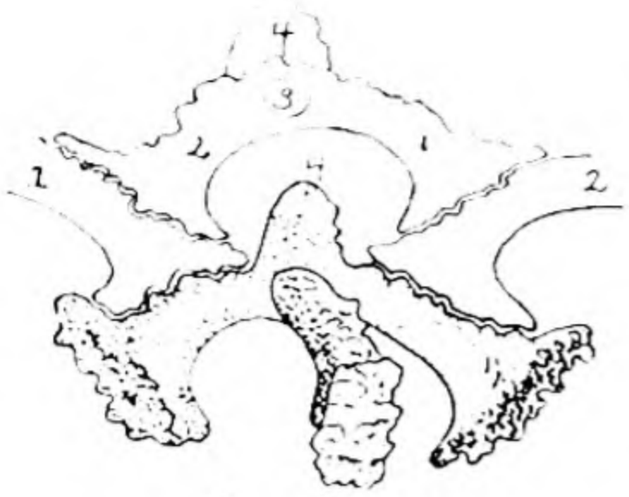
ZITTELELLA Ulrich and Everett 1890

(**Z. typicalis*). Simple, pedunculate, attached sponge, varying in shape from depressed obconical, turbinate or subspherical to subcylindrical, rarely lobate; upper surface with shallow central depression into which open numerous thin-walled vertical tubes that extend through to base of sponge; canal system consisting principally of a series of radiating canals which are closely arranged in vertical series, separated by spicular material from 1 to 3 times width of canals; canal arrangement gives sponge appearance of being divided by vertical fissures; differs from

PLATE 15

[Figures are x1 unless otherwise indicated.]

1, 2. Leptomitus lineatus [SMC 67]. Complete specimen (x1.5), and portion enlarged (x2). **3. Petrosites humilis** [JP 10]. A typical spicule (x220). **4. Eospongia roemeri** [GSA, SP 11]. **5, 6. Archaeoscyphia minganensis** [CGS, Pal Fos 1]. A nearly complete specimen, and a small portion of the wall somewhat enlarged. **7. Choia carteri** (x2) [SMC 67]. **8, 9. Zittelella varians** [Wag Free Inst Sc, B 13]. Top view and longitudinal section. **10–12. Hudsonospongia cyclostoma** [MCZ, B 86]. Spicules (x1, x10) and exterior. **13. Lissocoelia ramosa** [Photograph furnished by R. S. Bassler]. **14, 15. Astylospongia praemorsa** [Roemer: Sil Fauna W Tenn]. Top and side views. **16, 17. Nevadocoelia wistae** [Photograph furnished by R. S. Bassler]. Exterior, and portion of surface enlarged (x6). **18. Palaeomanon cratera** [Roemer: Sil Fauna W Tenn].



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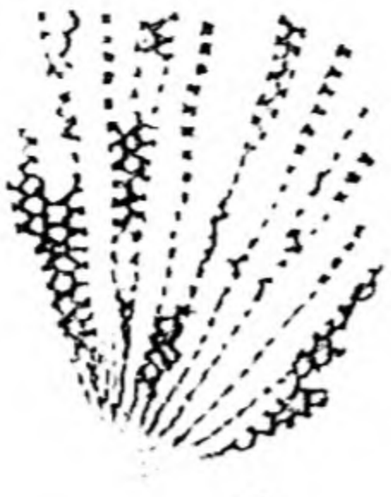

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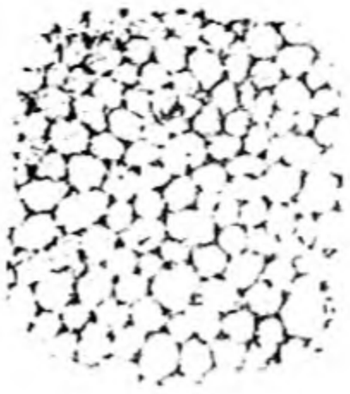

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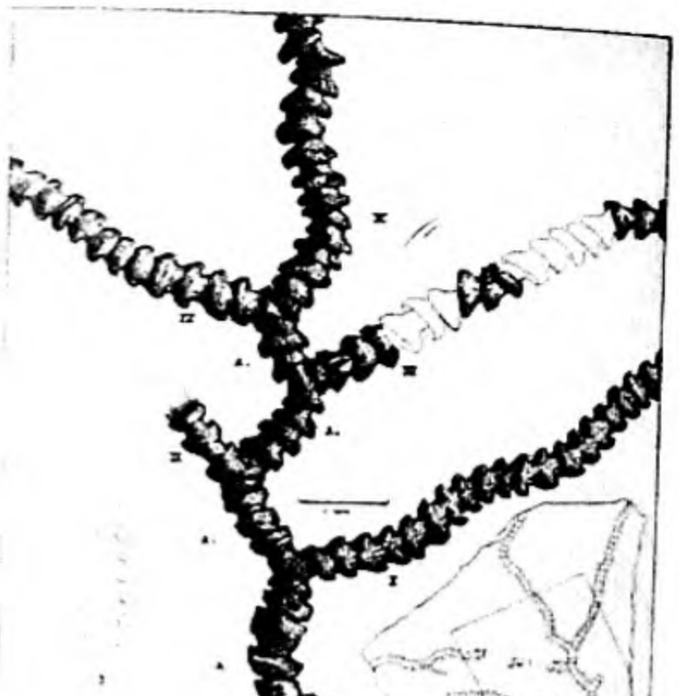

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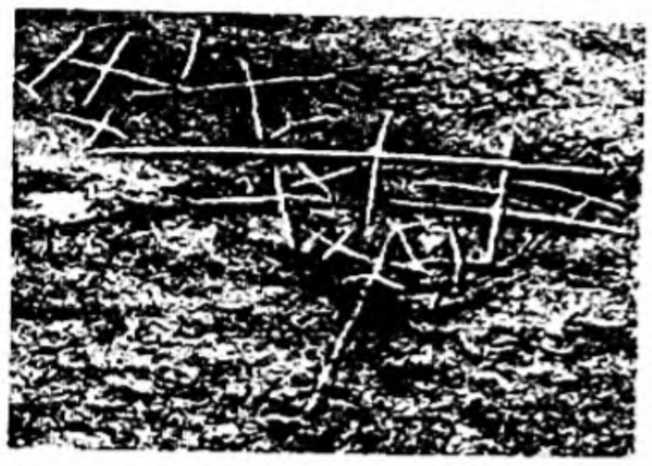

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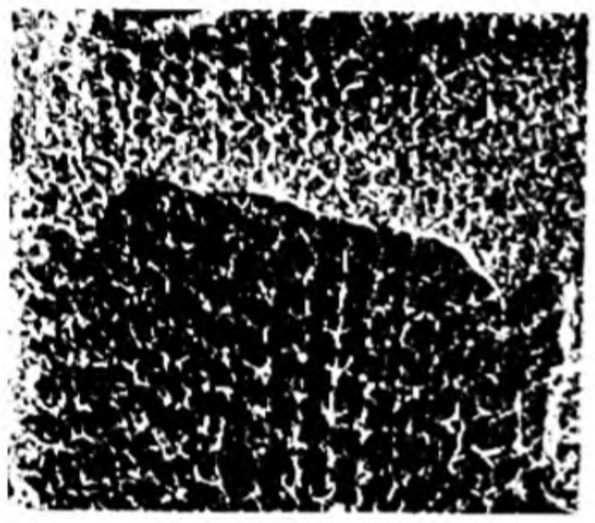

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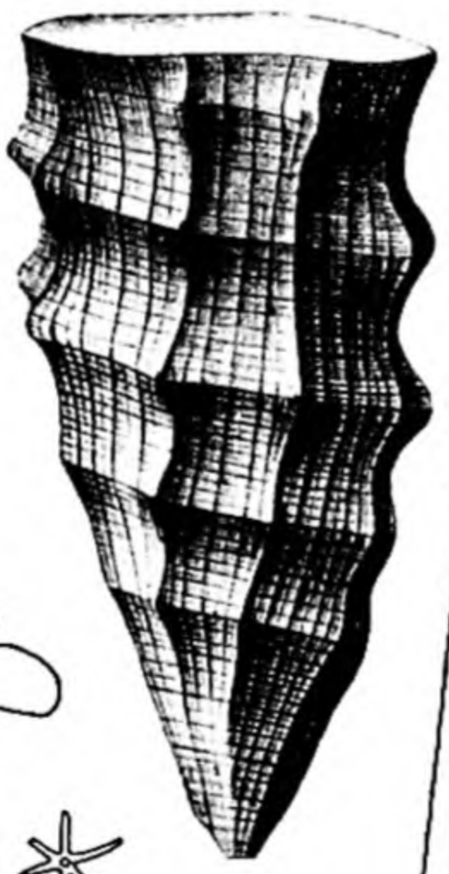

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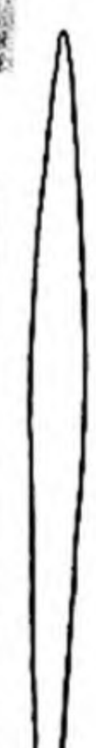

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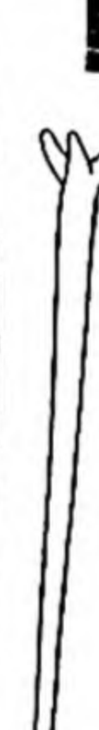

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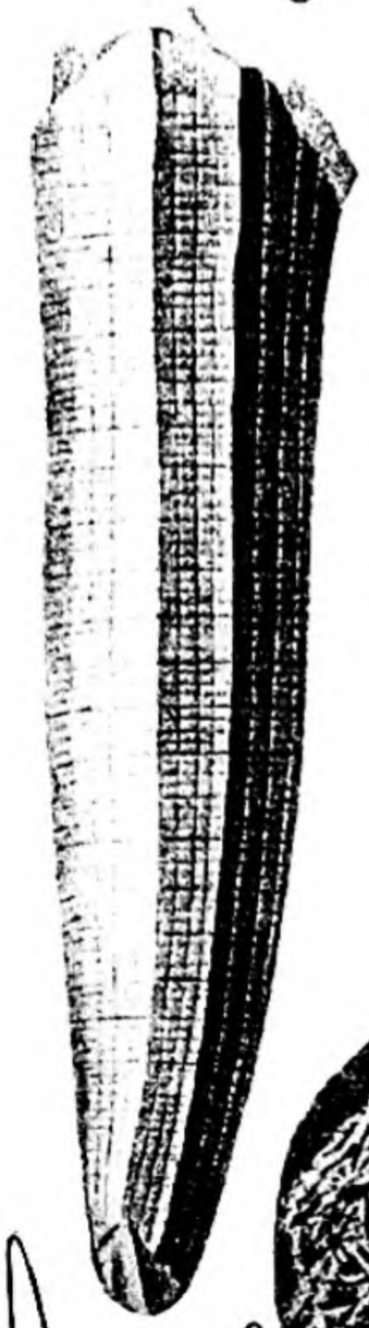

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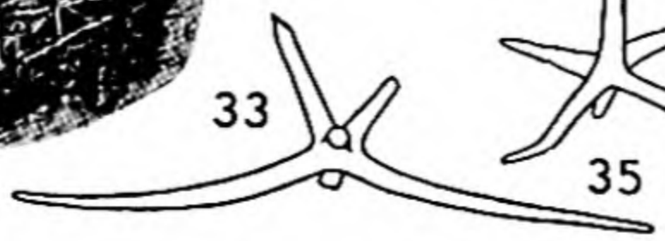

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Eospongia in possessing the conspicuous vertical radial structures just described. **Ord.** (Que.; Ill., Tenn.).

Z. varians (Billings) (**15**—8, 9). Dorsal depression conical, deep, reaching almost to bottom of individual; upper surface symmetrical, regularly curved; central depression occupies nearly one-third entire diameter; numerous regularly placed radial structures, between which are canals extending upward and outward; sponge also pierced by numerous transverse openings, so that each partition is really a sort of lattice. **Chazyan:** Mingan Islands, Que. (Mingan); Vt.

HUDSONOSPONGIA Raymond and Okulitch 1940

(**H. cyclostoma*). Unbranched, pyriform or obconical sponges, sometimes depressed; other features illustrated by genotype. **L. Ord.** (eastern N. America).

***H. cyclostoma** Raymond and Okulitch (**15**—10–12). Symmetrically pyriform with small shallow dorsal depression; internal structure shows numerous nearly vertical canals in axial region and other smaller ones which radiate upward and outward from these to surface; spaces between canals filled by a spicular meshwork; spicules tetracladine; superficially differs from *Eospongia roemeri* in having greatest diameter near top and in being much smaller and more nearly obconical, but fundamentally the arrangement of canals is entirely different. **Chazyan:** Tenn. (Lenoir).

ASTYLOSPONGIA Roemer 1860

(**Siphonia praemorsa* Goldfuss). Free, spherical, with shallow dorsal depression; base evenly rounded; surface furrowed by large canals and pitted with pores which terminate many fine radial canals; spicules tetraxial and branching, with their nodes enlarged into knots. **Ord.?, Sil.** (Ont.; Ind., Ill., Ky., Tenn.).

***A. praemorsa** (Roemer) (**15**—14, 15). **Niagaran:** Ind., Tenn.

PALAEOMANON Roemer 1860

(**Siphonia cratera*). Like *Astylospongia*, but bowl-shaped, with shallower and wider cloacal depression; surficial furrows usually not deep; entire surface covered with pores. **Sil.**

***P. cratera** (Roemer) (**15**—18). **Niagaran:** Tenn.

HINDIA Duncan 1879

(**H. fibrosa*). Free, spheroidal; spicules form a series of bifurcating, straight canals radiating from center and opening at surface. **Ord.–Dev.** (Eastern Canada; N. Y., N. J., Va., Ky., Tenn., Wis., Ill., Minn., Ia.; England; Gotland; Germany; Russia).

***H. fibrosa** Duncan (**16**—1). Spheroidal, about 25 mm in diameter; surface covered with very small, irregular polygonal openings. **Ord.:** Anticosti. **Sil.** and early **Dev.:** Many localities in eastern Canada and U. S. A.

H. parva Ulrich (**16**—2–4). Smaller than preceding; radiating canals not over 0.27 mm in diameter, somewhat smaller than in preceding. **Ord.:** Black River of Wis., Minn.; Trenton of N. J., Va., Ky., Tenn.; Maquoketa of Ia.

Order Hexactinellida. Skeleton composed of detached or fused siliceous hexaxial spicules, which may be united into a rigid framework by secondary silica but never by spongin; many fossil species fall in this order. **Camb.–Recent.**

PROTOSPONGIA Salter 1864

(**P. fenestrata*). Sponge globular with slender root tuft; osculum at summit; spicules forming a reticulate meshwork. **L.** and **M. Camb.** (Newf.; N. B., Que.; N. Y., Ga., Ala., Idaho, Utah; B. C.; Wales; Sweden; China).

***P. fenestrata** Salter (**16**—6). Same range and distribution as given for genus, except absence in Georgia and Idaho.

KIWETINOKIA Walcott 1920

(**K. utahensis*). Sponge probably sacklike and anchored to mud by long spicules; preserved as tangled mass of long slender rods and cruciform and triradiate spicules. **M. Camb.** (Que.?; Idaho, Utah).

***K. utahensis** Walcott (**16**—11). **M. Camb.:** Utah (Marjum, Ophir, Ute).

VAUXIA Walcott 1920

(**V. gracilenta*). Elongate, cylindrical, single or branching, crateriform and frondose, thin-walled sponges; skeleton of spicules (tetraxons) bearing two main rays which combine to form strong vertical sides of irregular roughly outlined quadrangles with interspaces more or less filled in with minute spic-

PLATE 16

[Spicules are x15 and other figures x1, and after Weller [JP 4] unless otherwise indicated.]

1–4. Hindia spp. 1. H. fibrosa [Girty after Rauff; N Y St Mus, An Rp 48 (2)]. Much enlarged spicules. **2–4. H. parva** [Minn G S 3 (1)]. Transverse and tangential sections much enlarged, and three complete specimens. **5. Titusvillia drakei** [JP 13]. (1) Part of colony showing branches and individual cups; (2) holotype slab; (3) longitudinal composite section through parts of a skeleton (x0.25). **6. Protospongia fenestrata** [SMC 67]. Spicules (x3). **7, 8. Vauxia gracilenta** [SMC 67]. Nearly complete specimen (x2), and enlarged portion (x6) of a larger specimen. **9, 10. Asteractinella audax.** A large spicule and a small flesh spicule. **11. Kiwetinokia utahensis** [SMC 67]. Spicules (x3). **12, 13. Chancelloria eros** [SMC 67]. Nearly complete specimen, and spicules (x6). **14. Rhaklstella alba. 15. Prismodictya telum** [N Y St Mus, M 2]. **16. Hyalostella diabola. 17, 18. Tholiasterella? trunca. 19. Hydnoceras tuberosum** (x0.5) [N Y St Mus, M 2]. **20–26. Geodites spp. 20, 22. G. carbonarius. 21, 26. G. pateus. 23. G.? deflecterus. 24, 25. G.? bifurcatus. 27. Prismodictya prismatica** [N Y St Mus, M 2]. **28–30. Reniera spp. 28. R. siliqua. 29. R. phaseola. 30. R. arca. 31. Eiffelia globosa** [SMC 67]. Flattened specimen showing osculum at top (x3). **32–35. Hexactinellida delicatula. 36. Dictyospongia sceptrum** (x0.3) [N Y St Mus, M 2]. **37, 38. Multivasculatus ovatus** [Wag Free Inst Sc, B 15]. Top and side views (x0.5).

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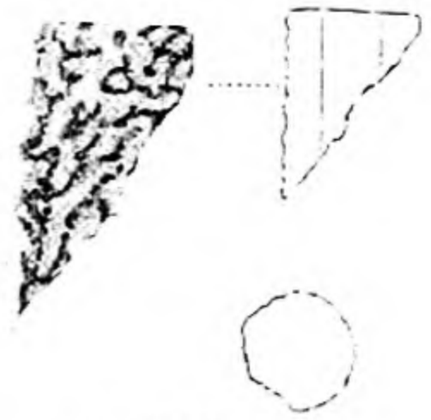
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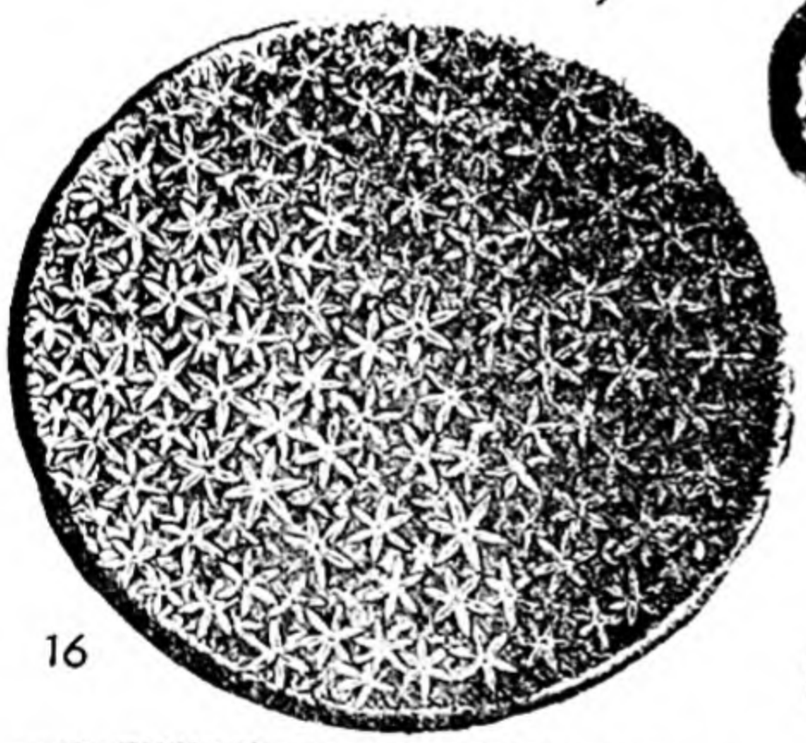
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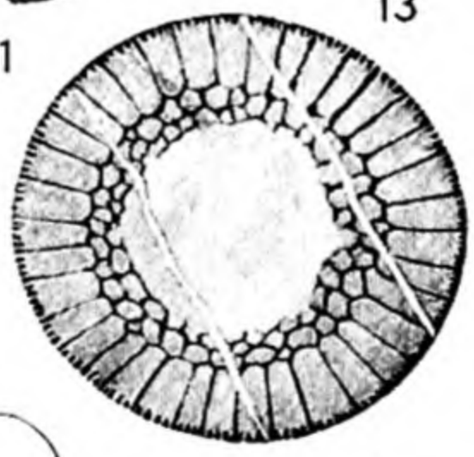
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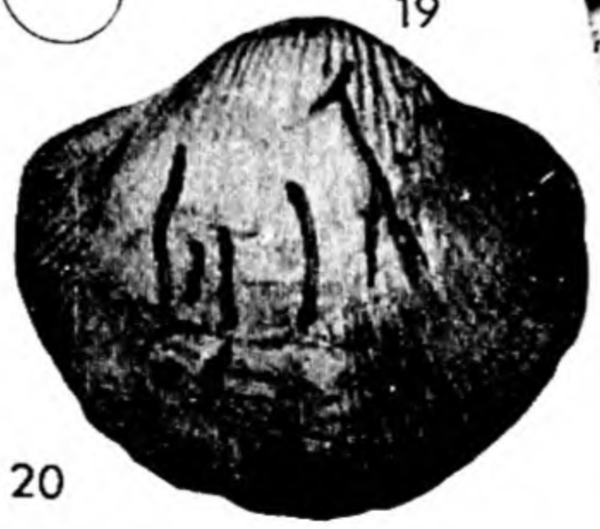
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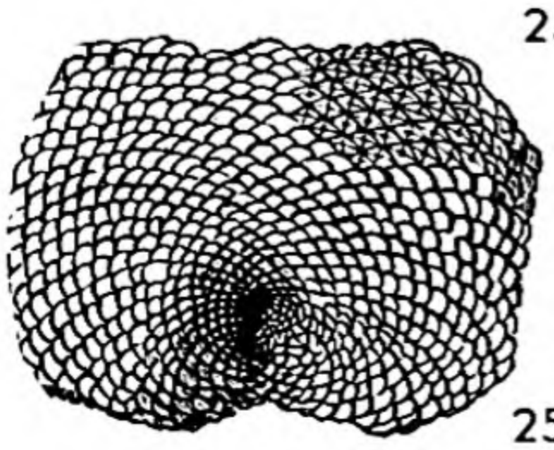
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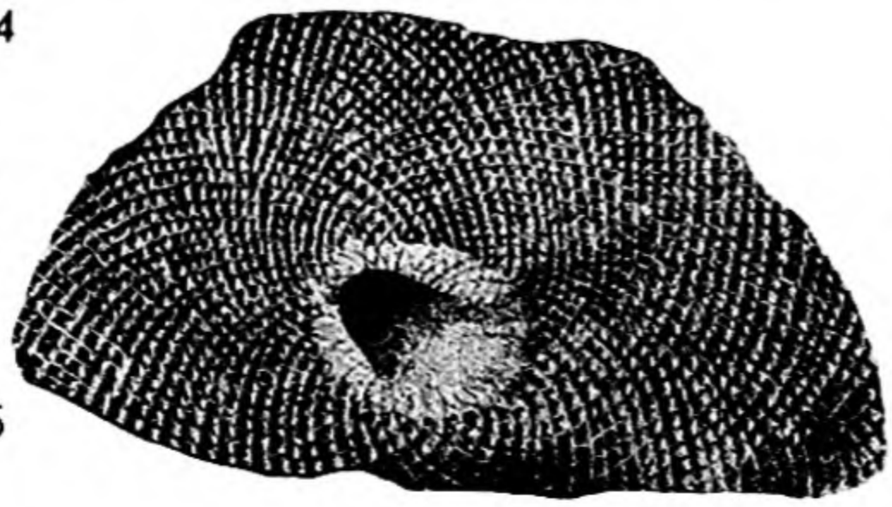
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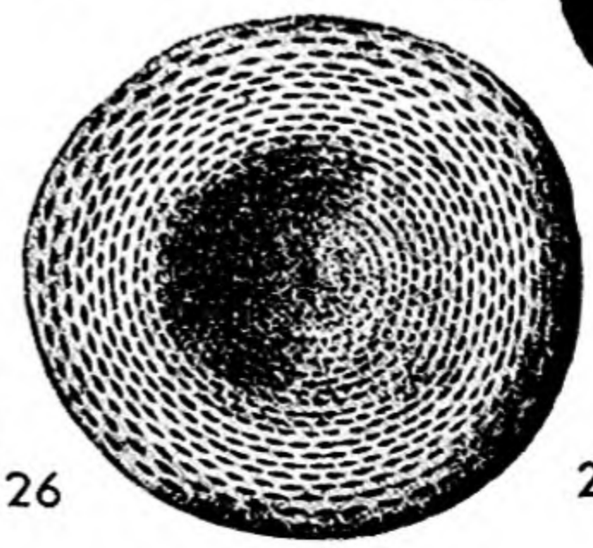
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ules of various outlines; third ray slender, extending across between vertical lines to form a straight or slightly curved transverse boundary of meshes; axial ray extends inward. **M. Camb.**

***V. gracilenta** Walcott (**16**—7, 8). **Burgess:** B. C.

EIFFELIA Walcott 1920

(**E. globosa*). Spheroidal or irregularly globular, with six-rayed spicules forming a close irregular mesh; stellate hexaxons with rays in one plane and a vertical ray; differs from *Astraeospongia* in being formed of a relatively thin layer of spicules, more or less regularly arranged in an outer layer, rather than an almost solid inner skeleton. **M. Camb.**

***E. globosa** Walcott (**16**—31). **Burgess:** B. C.

CHANCELLORIA Walcott 1920

(**C. eros*). Elongate, tubular or finger-shaped, or broad and frondose; large spicules umbrella-shaped, with 4 to 9 principal horizontal rays and a central disk or vertical axis with an inner axial ray and possibly an outer ray; also marginal spicules with 2 or 3 slender rays. **M.** and **U. Camb.** (Mo.; B. C.).

***C. eros** Walcott (**16**—12, 13). **Burgess:** B. C.

C. aurora Lochman. **U. Camb.:** Mo. (Bonneterre).

MULTIVASCULATUS Howell and Van Houten 1940

(**M. ovatus*). Apparently colonial siliceous sponge with thin incrusting layer, from which rose many vaselike branches, each with a single osculum; skeletons of branches composed of hexaxons, curved rods with papillose surface and five very much smaller rays at one end, and straight rods; few, if any, spicules in basal layer. **Camb.**

***M. ovatus** H and V (**16**—37, 38). **U. Camb.:** Wyo. (Gallatin).

DICTYOSPONGIA Hall and Clarke 1898

(**Dictyophyton sceptrum* Hall). Subcylindrical, very gradually expanding; smooth, without ornamentation except the reticulated meshwork of spicular threads; prism faces sometimes very obscurely developed toward summit; fossils occur chiefly as internal fillings and impressions. **Dev.** (characteristic of the Chemung; also occurs in upper Portage)–**Miss.** (N. Y., Ia.?).

***D. sceptrum** (Hall) (**16**—36). Elongate, usually abnormally compressed; surface covered with coarse, transverse, spicular bands 10 to 15 mm apart and crossed by less conspicuous vertical bands about 5 mm apart. **Chemung:** N. Y.

PRISMODICTYA Hall and Clarke 1898

(**Dictyophyton telum* Hall). Elongate, usually slender, gradually expanding from acute base; surface sharply prismatic, with eight faces reticulated by spicular threads and rarely ornamented with inconspicuous nodes; occurs as internal fillings and impressions. **Dev.** (characteristic of Chemung; also occurs in upper Portage)–**Miss.** (N. Y., Pa.).

***P. telum** (Hall) (**16**—15). **Chemung:** N. Y.

P. prismatica (Hall) (**16**—27). **Chemung:** N. Y., Pa.

HYDNOCERAS Conrad 1842

(**H. tuberosum*). Obconical, more or less rapidly expanding from acute base; surface at first smooth except for reticulated spicular threads, but soon developing eight prism faces and prominent nodes in horizontal and vertical rows; nodes usually lie at intersection of adjoining prism faces and are connected in vertical rows by short prominent lamellae; occur as internal fillings and impressions. **Dev.** (characteristic of Chemung; also in Portage)–**Miss.** [Waverly] (N. Y., Pa.).

***H. tuberosum** Conrad (**16**—19). **Chemung:** N. Y.

TITUSVILLIA Caster 1939

(**T. drakei*). Branching colony with individual branches composed of cuplike nodes (each cup corresponds to an individual sponge); nodes connected by a central cloaca, and variously oriented; branches leave main zigzag axis at about 120° intervals; surface of external mold reticulate. **Miss.** (Penn-York embayment of eastern U.S.A.) (closely related antecedent genera occur in the Upper Devonian of the same region).

***T. drakei** Caster (**16**—5). **Cussewago:** Pa. (Tidioute).

RHAKISTELLA Weller 1930

(**R. alba*). Isolated hexactinellid symmetrical spicules characterized by small, equal-sized and equal-spaced spines; one or more of the six primary rays may bifurcate sharply. **L. Penn.**

***R. alba** Weller (**16**—14). **L. Penn.:** Ill.

PLATE 17

[Figures are x1 and after Walcott [USGS, B 30] unless otherwise indicated.]

1–3. Camarocladia dichotoma [Ill G S 8]. Several fragments, and enlarged longitudinal and transverse sections (x9). **4, 5. Heterocoelia beedei** [USNM, Pr 34]. Longitudinal section (x3) and exterior. **6, 7. Archeocyathus altanticus.** Longitudinal and transverse sections (x4) and outlines. **8, 9. Amblysiphonella prosseri** [Am G 20]. Longitudinal section and exterior. **10, 11. Meandrostia kansasensis.** Exterior [U Tex B 3201]; transverse section of a smaller specimen (x2) [USNM, Pr 34]. **12, 13. Girtycoelia typica** [U Tex B 3201]. Exterior and longitudinal section. **14, 15. Archeocyathus rensselaericus.** Nearly complete specimen (x3) and highly magnified portion of a wall. **16, 17. Astraeospongia meniscus** [Roemer: Sil Fauna W Tenn]. Top and side views. **18. Clionolithes hackberryensis** [Am Mid Nat 13]. Sponge boring on brachiopod shell. **19. Ethmophyllum whitneyi.** Transverse section (x1, x4). **20. Clionoides thomasi** [Am Mid Nat 13]. Sponge boring in *Atrypa*. **21. Nidulites pyriformis** [Photograph furnished by R. S. Bassler]. **22, 23. Cambrocyathus profundus.** Longitudinal section, and partial transverse section considerably enlarged. **24, 25. Receptaculites occidentalis** [CGS, Pal Fos 1]. Lateral and top views of a fragment. **26. Receptaculites owenl** (x0.5) [Minn G S 3 (1)]. **27, 28. Ischadites iowensis** [Minn G S 3 (1)]. Top and side views.

ISOLATED SILICEOUS SPICULES

J. M. Weller (1930) has reported an interesting fauna of siliceous sponge spicules from the Lower Pennsylvanian of southern Indiana and Illinois. These isolated spicules are representative of what may be expected at other horizons in future investigations; hence the more typical ones are listed and illustrated here, but it is not considered necessary to characterize the genera. Unless otherwise indicated, the species is Weller's.

Monactinellida:

Reniera arca (**16**—30). Ind. **R. siliqua** (**16**—28). Ill. **R. phaseola** (**16**—29). Ill.

Tetractinellida:

Geodites pateus (**16**—21, 26). Ind. **G. carbonarius** (Ulrich) (**16**—20, 22). Ill. **G.? deflecterus** (**16**—23). Ind. **G.? bifurcatus** (**16**—24, 25). Ind.

Hexactinellida:

Hyalostellia diabola (**16**—16). Ill. **Hexactinellida delicatula** (Ulrich) (**16**—32–35). Ill.

Heteractinellida:

Asteractinella audax (**16**—9, 10). Ind. **Tholiasterella? trunca** (**16**—17, 18). Ind.

CLASS CALCISPONGIAE

Skeleton composed of one-, three-, or four-rayed calcareous spicules which are readily soluble; individual spicules not commonly preserved as fossils; usual fossils are those forms in which the spicules are fused together to form a rigid skeleton. **Camb.–Recent.**

CAMAROCLADIA Ulrich and Everett 1889

(**C. dichotoma*). Ramose, consisting of small, subcylindrical branching stems; interior with comparatively large, but short subcylindrical canals or cavities, which wind about in an irregular manner before opening at surface of branches; canals separated by cribrose, spiculate walls; three-rayed spicules in canals. **Camb., Ord.**

***C. dichotoma** Ulrich and Everett (**17**—1–3). **M. Ord.:** Ill. (Platteville).

C. rugosa Ulrich. Branches range in width from 5 to over 12 mm; distance between bifurcations greatly variable; within each branch is a subcylindrical rod with constrictions 3 to 6 mm apart, surrounded by a series of septalike partitions (usually 2 per annulation). **M. Ord.** (Black River): Pa., Ky., Minn.

HETEROCOELIA Girty 1908

(**H. beedei*). Stemlike, consisting of a row of small, rather distinctly separated spherical cells; sometimes branching; through each stem is a central cloaca, continuing from cell to cell and perforate; cell walls distinct, perforated by large spoutlike ostia. **Penn.**

***H. beedei** Girty (= **Amblysiphonella prosseri** Beede [part]) (**17**—4, 5). **Penn.:** Kan. (Allen), Tex. (Graford, Gaptank).

AMBLYSIPHONELLA Steinmann 1882

(**A. prosseri* Clarke). Skeleton a series of subspherical cells in a straight or curved stem; surface with dermal pores but without ostia — the reverse of *Heterocoelia*; a prominent cylindrical cloaca continuous from chamber to chamber, walls perforate; internal structure vesiculose. **Penn.**

***A. prosseri** Clarke (**17**—8, 9). **U. Penn.:** Neb. (Wabaunsee).

GIRTYCOELIA King 1932

(**G. typica*). Overlapping spheres arranged to form more or less contorted, occasionally branching stems; segments perforate; externally somewhat like *Amblysiphonella*, but internally quite different. **Penn.**

***G. typica** King (**17**–12, 13). **Penn.:** Tex. (Graford).

MAEANDROSTIA Girty 1908

(**M. kansasensis*). Stemlike, contorted and branching large continuous cloaca; walls thick, structureless; imperforate except for vermiform chambers which open to surface or communicate with each other and the cloaca. **Penn.**

***M. kansasensis** Girty (**17**—10, 11). **Penn.:** Kan. (Allen), Tex. (Graford).

CLASS PLEOSPONGIA

(**CYATHOSPONGIA** Okulitch; Archaeocyathids of authors, *Archaeoscyphia* excepted).

Conical to cylindrical, with double wall inclosing central axial cavity; walls perforate, with space between septate; attached by base. **Camb.**

ARCHEOCYATHUS Billings 1861

(= ARCHAEOCYATHUS Roemer 1880; SPIROCYATHUS Hinde 1889)

(**A. atlanticus*). Skeleton simple, elongate, cylindro-conical, concentrically corrugated; cup deep; outer wall porous; septa of irregular sclerites, forming porous structure, bounded by inner wall of similar character; axial cavity without structure. **L. Camb.** (worldwide distribution).

***A. atlanticus** Billings (**17**—6, 7). Tapering cylindrical; outer wall fairly thick, perforated in places; inner wall very irregular in thickness, and penetrated by a few large canals; intervallum filled with irregular skeletal tissue, which separates winding and irregularly contracting and expanding canals; canals anastomose, extending from outside inward; no septa. **L. Camb.:** Labrador (Forteau); Vt.

A. rensselaericus (Walcott) (**17**—14, 15). Small, smooth, cylindro-conical; inner wall well marked; septa few and widely spaced. **L. Camb.:** Vt.?, N. Y., N. J.

ETHMOPHYLLUM Meek 1868

(**E. whitneyi*). Inner wall pierced by round canals directed upward and inward, appearing in transverse section as a double row of transected vesicles; well-defined vesicular zone at inner wall into which regular septa merge; septa straight. **L. Camb.**

***E. whitneyi** Meek (**17**—19). Subcylindrical; outer wall regularly porous; septa regular, merging into double row of vesicles on inner side. **L. Camb.:** Nev.

CAMBROCYATHUS Okulitch 1937

(**Archeocyathus profundus* Billings). Horn-shaped Pleospongia with simple radial parieties always connected by numerous synapticulae; simple inner wall; annulated outer wall. **L. Camb.** (N. America).

***C. profundus** (Billings) (**17**—22, 23). Outer and inner walls interconnected by over 150 septa, about 2 per mm; central cavity very deep; width of intervallum averaging 4 mm; width of inner cavity near top, over 30 mm; outer wall transversely annulated, with annulations 4 to 5 mm high and 5 to 7 mm apart, and longitudinally striated; both walls perforate; parieties or septa thin, straight, going directly from wall to wall, and bearing tiny pores. **L. Camb.:** Labrador.

SPONGE BORINGS

CLIONOLITHES Clarke 1908

(**C. radicans*). "Form genus," including borings, presumably by monactinellid sponges, which appear as tubes excavated in fossil brachiopod and mollusk shells and other organisms; tubes may radiate from a center or centers and branch or anastomose, and are rarely over 0.5 mm in diameter. **Dev.** (probably not restricted to this period).

C. hackberryensis (Thomas) (**17**—18). **Hackberry:** Ia.

CLIONOIDES Fenton and Fenton 1932

(**C. thomasi*). "Form genus," differing from *Clionolithes* in that tubes never radiate, though they branch. **Dev.** (probably not restricted to this period).

***C. thomasi** Fenton and Fenton (**17**—20). **Cedar Valley:** Ia.

INCERTAE SEDIS

Spongelike fossils representing extinct organisms which are believed to belong to the Porifera, but which cannot be placed in any recognized classes; uncertain taxonomic position, however, in no way detracts from their value as index fossils.

ASTRAEOSPONGIA Roemer 1860

(**Blumenbachium meniscus*). Thick-walled, bowl-shaped; upper surface concave, lower convex without traces of attachment; skeletal structure a felted mass of large, eight-rayed spicules, six rays of which are disposed in the same plane while the remaining two, projecting at right angles to the plane, are reduced to buttonlike prominences. **Sil.**

***A. meniscus** (Roemer) (**17**—16, 17). **Niagaran:** Ky. (Louisville), Tenn. (Brownsport).

RECEPTACULITES Blainville 1830

(**R. neptuni*). Globular to platter-shaped bodies containing a central cavity whose calcareous wall is composed of five-rayed spicules so arranged as to form rectangular cells between; usually only basal part of structure preserved, the complete form having been originally bowl-shaped or vaselike with contracted top; spicules with their extremities expanded and more or less flattened to form two surfaces of wall; arrangement of these extremities is in curved radiating lines, the lines crossing as in the engine-turned ornamentation of a watch. **Ord.–Dev.** [possibly younger] (Greenland; Arctic America; eastern Canada; widespread throughout U. S. A., especially in M. and U. Ordovician strata).

R. occidentalis Salter (**17**—24, 25). Skeleton forming flattened, saucerlike expansion; diameter as much as 20 cm (8 in.); thickness 4 mm at center and 12 mm at margin; shafts of cylindrical spicules about 1 mm thick. **Black River:** Arctic America; Que.; N. J., Pa., Md., Ky.

R. oweni Hall (**17**—26). Broad, ranging in diameter from a few centimeters to over half a meter (2 ft); consisting of a flat circular disk with small funnel-shaped depression above, corresponding to the narrow projecting base of attachment on under side; cell rows curving strongly as they radiate from center; cell apertures quadrangular at surface, becoming circular and decreasing in diameter toward center. **Black River, Trenton:** Arctic America; Que., Man.; Ind., Wis., Ill., and Ia., where it is the characteristic "Sunflower coral" in the Galena dolomite, Minn. to Mo.; a large variety of this species characterizes the Richmond, as in the Bighorn of Wyo.

ISCHADITES Lonsdale 1839

(**Tetragonis murchisoni* Eichwald). Differs from *Receptaculites* in having conical or ovate skeleton, with a small terminal aperture which usually is collapsed, and in lacking an inner layer. **Ord.–Dev.** (characteristic of M. Ord. in eastern Canada and throughout U. S. A.).

I. iowensis (Owen) (**17**—27, 28). Base concave; upper surface flatly dome-shaped or slightly depressed with an opening into the hollow cavity; small rhomboidal cells opening on surface in curved rows, intersecting at arches. **Trenton:** Wis., Ill., Minn., Ia. (Prosser), Mo.; Man.

NIDULITES Salter 1851

(**N. favus*). Generic characters well shown in species following. **Ord.** (eastern N. America; England).

N. pyriformis Bassler (**17**—21). Pyriform pedunculate bodies with an outer covering of hexagonal cup-like plates, each of which is deeply concave and marked off at surface by a sharp wall; interior hollow and frequently filled with crystalline calcite. **Chambersburg:** Pa., Md., Va.

CHAPTER IV

PHYLUM COELENTERATA

This phylum includes a large and varied group of living and extinct organisms which, throughout their long history that reaches back to the beginning of the Paleozoic, have lived in aquatic habitats, mainly as sessile benthos. Most groups have been marine, though a few now are adapted to fresh water and there may also have been similar adaptation at times during the past. The phylum includes both solitary and colonial organisms (*polyps*), with the latter much the more common. These colonial organisms occupy small cups which are in communication with each other and are bound together intimately into a great variety of exoskeletons. Most exoskeletons are calcareous (stromatoporoids, stony corals), but some are chitinous (graptolites, some corals and hydroids). There is an excellent fossil record of the phylum, and many of the species are important index fossils. The Coelenterata may be divided into six classes:

Class **Hydrozoa.** Hydroids and medusae.

Class **Stromatoporoidea.** Extinct organisms, possibly related to Hydrozoa; may also be ancient sponges.

Class **Graptozoa.** The extinct graptolites.

Class **Scyphozoa.** Jellyfish, which are known from Cambrian to Recent but are useless as index fossils, except for the **Conularida.**

Class **Anthozoa.** Corals.

Class **Ctenophora.** Comb-jellies, unknown as fossils.

CLASS HYDROZOA[1]

This class has three divisions: (1) the modern hydroids, which are delicate mosslike animals, mostly growing in branching clusters or colonies having a common stem or a common base composed of chitinous material; colony rarely fossilized; (2) the **Hydrocorallinae,** which secrete a dense, massive, calcareous exoskeleton; and (3) the **Siphonophora,** pelagic hydrozoans which have left little if any fossil record.

Order Hydrocorallinae. Dimorphic polyps secrete a massive, calcareous exoskeleton composed of calcareous fibers and having two kinds of tabulated, tubular openings — *gastropores* housing the feeding polyps and *dactylopores* housing the protective ones. Some forms, like *Millepora* (**18**—1–3), are very important reef builders, and fossils of this order are known from as early as the Triassic; none, however, is an index fossil unless *Millepora* is so considered for very recent times.

CLASS STROMATOPOROIDEA[2]

The name "Stromatoporoidea" has long been used for a group of extinct coral-like marine organisms which built extensive calcareous reefs (*bioherms*) and beds during the Silurian and Devonian, and whose remains occur commonly in shales and limestones throughout the Paleozoic, to which era they apparently are limited.

The exoskeleton (*coenosteum*) consists of hemispherical, spreading, incrusting, globular, and cylindrical masses of calcareous material which in some instances attain a diameter of 5 feet and a height as great or greater. The base of the coenosteum is commonly covered with a concentrically wrinkled crust or epitheca. The internal structure consists of

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[1] **Kieslinger, A.,** Medusae fossiles: *Fos Cat,* pars 26: 1–20, 1924. **Kühn, O.,** Hydrozoa: *Fos Cat,* pars 36: 1–116, 1928; Hydrozoa, in **O. H. Schindewolf's** Handbuch der Palaozoologie, Bd 2A: A1–A68, 1939 [Berlin]. **Walcott, C. D.,** Fossil medusae: *USGS,* M 30: 1–201, il, 1898.

[2] **Fenton, C. L.,** Niagaran stromatoporoid reefs of the Chicago region: *Am Mid Nat* 12: 203–212, 1931. **Fenton, M. A.,** A Devonian stromatoporoid reef [Petoskey, Michigan]: *Am Mid Nat* 12: 195–202, 1931. **Heinrich, M.,** On the structure and classification of the Stromatoporoidea: *N Jahrb f Min,* etc., 1914, No. 23: 732–736, 1916 [Translated by **C. M. LeVene** in *JG* 24: 57–60, 1916]. **Hickson, S. J.,** On *Gypsina plana* and on the systematic position of the stromatoporoids: *QJ Microscop Soc* 76 (3), 1934. **Kühn, O.,** Hydrozoa, in **O. H. Schindewolf's** Handbuch der Palaozoologie, Bd 2A: A1–A168, 1939 [Berlin]. **Nicholson, H. A.,** On some new or imperfectly known species of stromatoporoids: *An Mag N H* (5) 19: 1–17, 1887; A monograph of British stromatoporoids: *Paleontogr Soc* 39, 42, 44, 46, il, 1886–1892. **Nicholson, H. A.,** and **Murie J.,** On the minute structure of *Stromatopora* and its allies: *Linn Soc, J Zool* 14: 187–246, il, 1878. **Parks, W. A.,** Stromatoporoids of the Guelph formation in Ontario: *Univ Toronto Stud,* gs 4: 1–40, il, 1907; Niagara stromatoporoids: Idem, gs 5: 1–68, il, 1908; Silurian stromatoporoids of America (exclusive of Niagara and Guelph): Idem, gs 6: 1–52, il, 1909; Ordovician stromatoporoids of America: Idem, gs 7: 1–52, il, 1910; Notes on Silurian stromatoporoids from Hudson's Bay: *Ottawa Nat* 22: 25–29, 1908; New species of stromatoporoids from Silurian of Baie des Chaleurs: *Univ Toronto Stud,* gs 33: 1–40, il, 1933; Systematic position of the Stromatoporoidea: *JP* 9: 18–30, il, 1935; Devonian stromatoporoids of North America: *Univ Toronto Stud,* gs 39: 1–125, il, 1936. **Raymond, P. E.,** A *Beatricea*-like organism from the Middle Ordovician: *CGS, Mus* B 5: 1–10, il, 1914; Further notes on *Beatricea*-like organisms: *MCZ (Harvard),* B 55: 165–213 [177–184], il, 1931. **Schuchert, C.,** The proper name for the fossil hydroid *Beatricea: AJS* (4) 47: 293–296, 1919. **Rominger, C. L.,** On the minute structure of *Stromatopora* and its allies: *Ac N Sc Phila,* Pr 1886: 39–56, 1886?. **Twitchell, G. B.,** Affinities of the true stromatoporoids [Abst]: *Ohio Ac Sc,* Pr 8: 172, 1928; *Ohio J Sc* 28: 150, 1928; Structure and relationships of the true stromatoporoids: *Am Mid Nat* 11: 270–306, il, 1928–1929. **Wells, J. W.,** A new species of stromatoporoid from the Buda limestone of Central Texas: *JP* 8: 169–170, 1934. **Whiteaves, J. F.,** Canadian stromatoporoids: *Can Rec Sc* 7: 129–146, 1896.

numerous concentric, undulating laminae, separated by interspaces and supported by radial pillars. In some forms the laminae are disposed concentric to a camerate axial tube. Sections cut across a coenosteum typically have a netlike or cellular appearance, and in many genera the laminae are well enough developed to give the section a strongly layered aspect (*Stromatopora*); in fact, in a few genera the laminae are grouped into thick strata or *latilaminae*, which exfoliate upon weathering. Both laminae and pillars may be traversed by minute canals, or they may be massive and imperforate. In some forms both radial and concentric or horizontal elements are vague and the entire internal structure is a ramifying or labyrinthine mass of fibers and curved, platelike elements. The surfaces of the laminae are frequently marked by numerous pores, tubercles, granules, blunt rounded prominences (*mamelons*) or blunt spines, and shallow furrows radiating from a center. The last-named structure, incised as it were in the lamina, resembles a star and is designated an *astrorhiza*.

At present there is no satisfactory complete classification of the Stromatoporoidea, largely because of the heterogeneity of the genera grouped in the "class." The following three divisions will be used here: Stromotoporoidea vera, Beatricidae, and Incertae sedis.

STROMATOPORIDEA VERA ("True stromatoporoids"). The true stromatoporoids have long been considered ancient and extinct relatives of the modern hydrocorallines (e.g. *Millepora*) and of *Hydractinia*, an aberrant hydroid. Though recent investigations by Twitchell, Parks, and Hickson have thrown considerable doubt on this supposed relationship, the older taxonomic relations are used here, but the authors fully realize that some if not all of the genera described below may be sponges or a type of organism other than coelenterates.

ACTINOSTROMA Nicholson 1885

(**A. clathratum*). Laminae consisting of meshwork of massive fibers; radial pillars more or less continuous (passing continuously through a number of laminae and interlaminar spaces), subequally spaced, and generally projecting on the surface as granules or tubercles; in transverse section, pillars and laminae forming more or less regular series of rectangular meshes; astrorhizae present or apparently absent. **Ord.?, Sil., Dev.** (widespread throughout eastern Canada; N. Y., Ill., Ia.).

A. tenuifilatum Parks (**18**—4–6). Laminae thin, 8 to 10 in 1 mm, with interspaces variable in width. **Niagaran:** E. Canada; Great Lakes region.

A. expansum (Hall and Whitfield) (**18**—7). Large colonies as much as a meter in diameter with undulating surface covered by low mamelons 10 to 13 mm from center to center. **U. Dev.:** E. Canada; Ia.

CLATHRODICTYON Nicholson and Murie 1878

(**C. vesiculosum*). Coenosteum variable in shape, size, and regularity of structure; laminae a meshwork similar to *Actinostroma*; radial pillars usually limited to one interlaminar space; astrorhizae frequently well developed; transverse section often appearing vesiculose. The following genetic series has been suggested by Parks (1936, 46), and representative species are listed below:

CLATHRODICTYON. With primary laminae intact and with pillars expanding above and separating into strands. ANOSTYLOSTROMA Parks 1936. (**A. hamiltonense* Parks) (**18**—8, 9), from the **Hamilton** of Michigan — with pillars further expanding above, breaking up into reticulations, spreading on the under side of the primary laminae, and becoming superimposed; descended from *Clathrodictyon*. TRUPETOSTROMA Parks 1936. (**T. warreni* Parks) (**18**—10, 11) from the **M. Dev.**, Great Slave Lake — with pillars superimposed, expanding above and below, and tending to obliterate the primary laminae; pillars and secondary laminae with vacuities; large openings in secondary laminae; descended from *Clathrodictyon* through *Anostylostroma*.

Clathrodictyon is by far the most abundant of the three genera just characterized and has been reported from Silurian and Devonian strata in Greenland, from many localities throughout eastern Canada and eastern and central United States, and from Great Britain and the Baltic region. It is commonly a reef builder.

***C. vesiculosum** Nicholson and Murie (**18**—12). Coenosteum a laminar or hemispheroidal mass with concentrically wrinkled epitheca, ranging in diameter from a few cm to as much as 30 cm, and half those dimensions in thickness; rounded prominences lacking; astrorhizae small and with centers 3 to 5 mm apart, 9 to 11 laminae in 1 mm. **L. Sil.:** Ont. (Alexandrian?). **M. Sil.** (Niagaran): Griffiths Island, Grinnell Land; Bessels Bay, Greenland; Southampton Island, Hudson Bay; Anticosti; Que. and Ont.; N. Y. to Ia. and Mo.; Great Britain.

C. vesiculosum minutum (Rominger) (**18**—13). **Niagaran:** N. B. (LaVeille), Que.

C. cystosum Rominger (**18**—14). Like preceding two forms but with "cystose" structure. **Niagaran:** Greenland; Drummond Island, Manitoulin Island, and general Great Lakes region; ?Ky.

C. striatellum (Orbigny) (**18**—17, 18). Laminar or hemispheroidal coenosteum with concentrically wrinkled epitheca; surface undulating but without mamelons; laminae five to 1 mm; radial pillars like spines growing downward from bottom of laminae; usually called *Stromatopora concentrica* by early investigators. **Niagaran:** Southampton Island, Hudson Bay; Ont.; N. Y., Great Lakes region. **Wenlock** of Great Britain and Gotland.

C. ostiolatum Nicholson. Differs from preceding in having nipplelike elevations which represent

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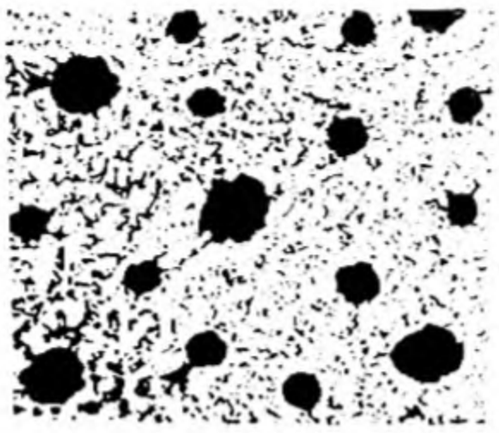
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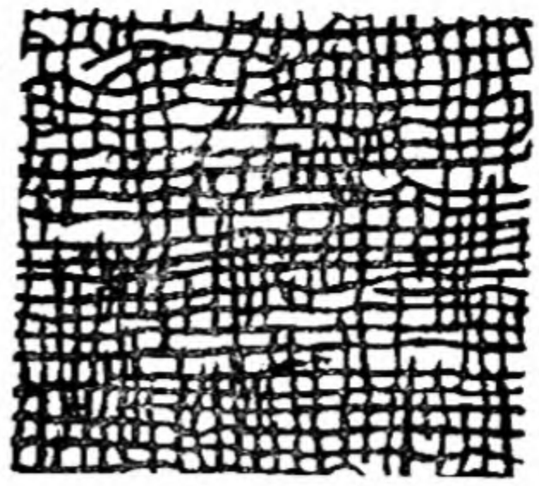
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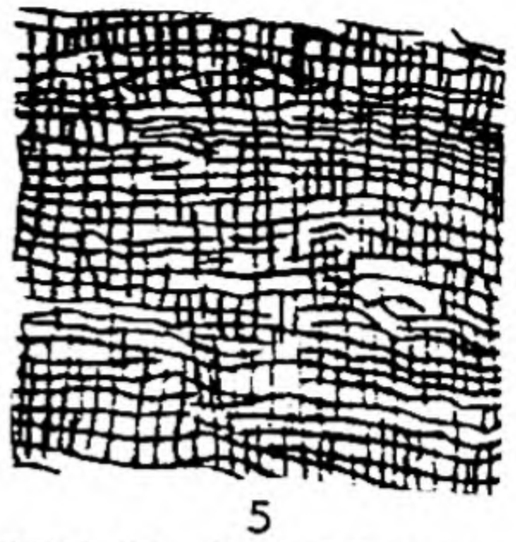
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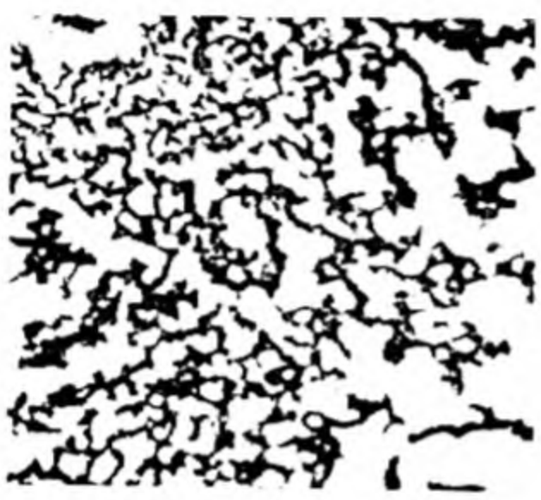
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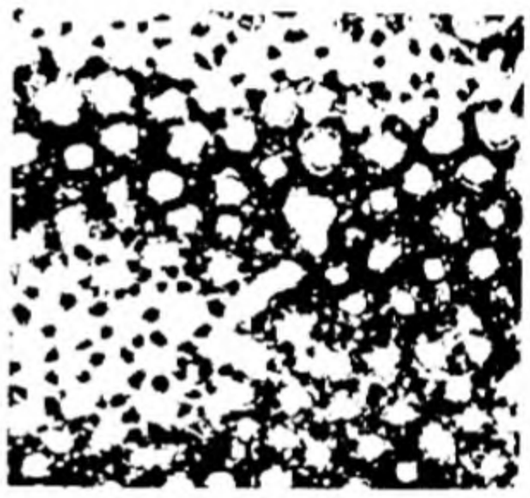
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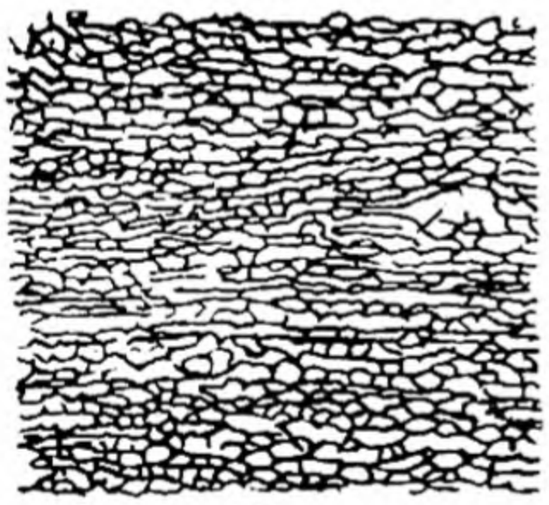
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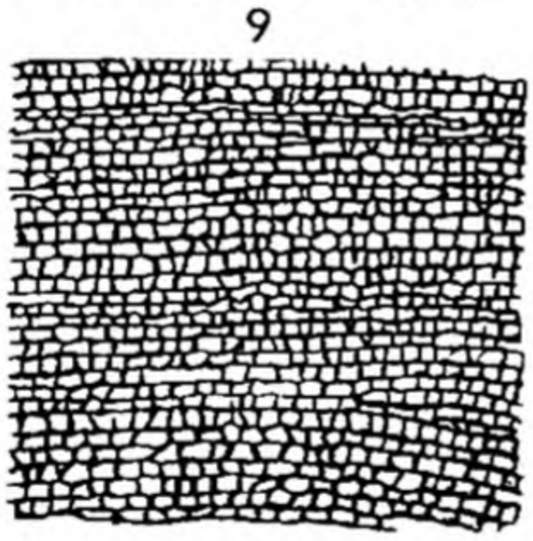
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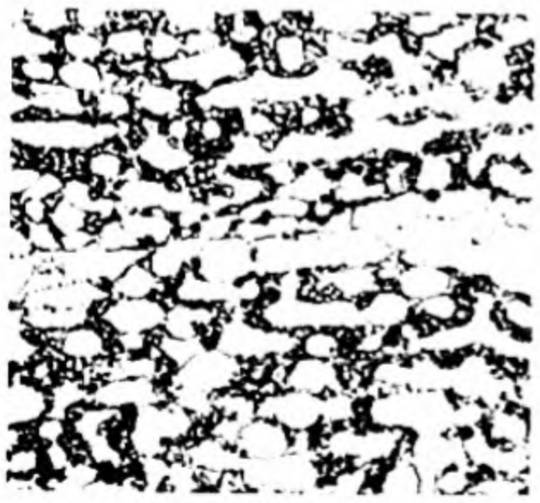
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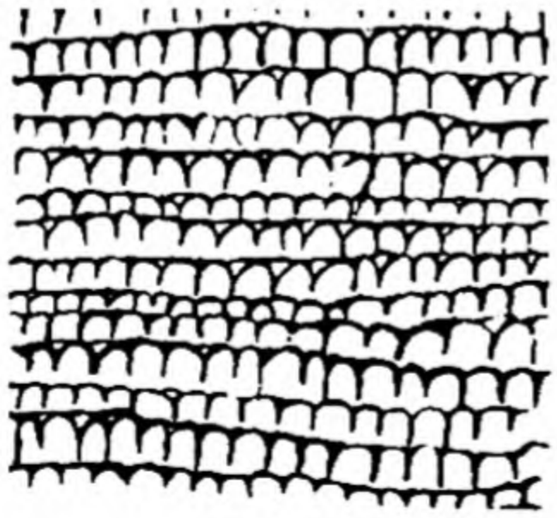
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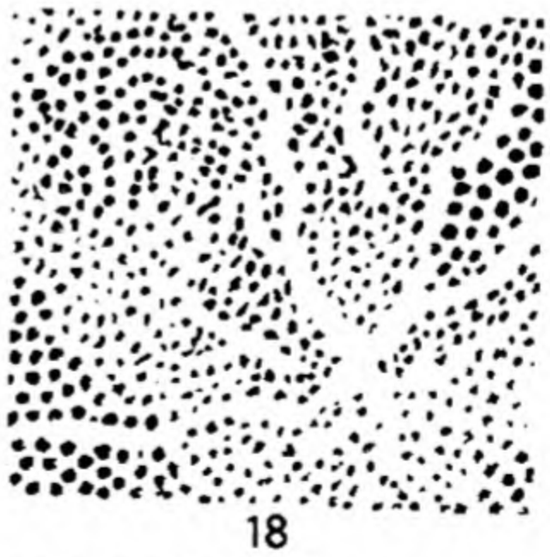
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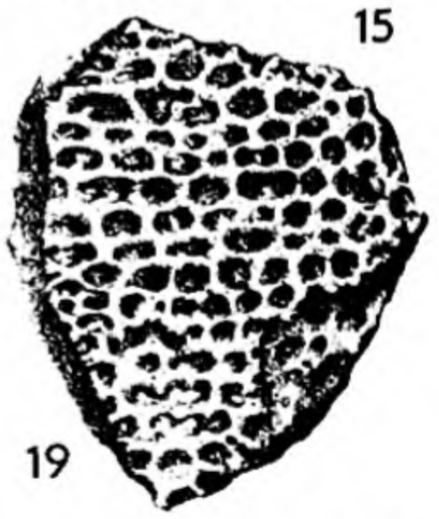
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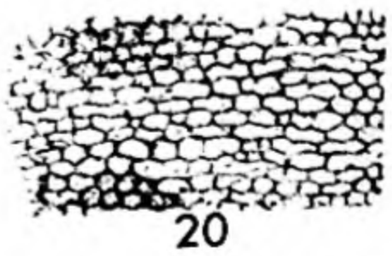
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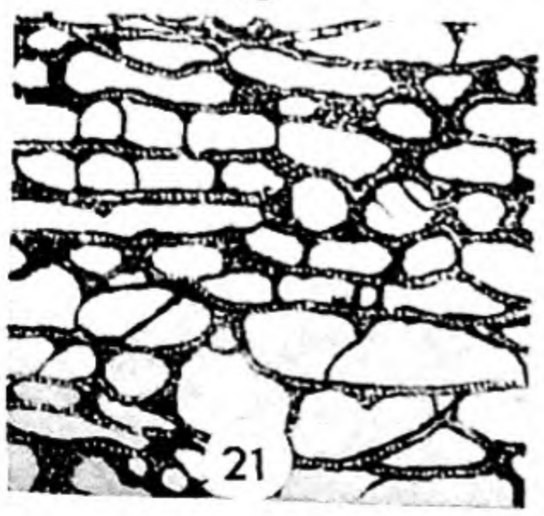
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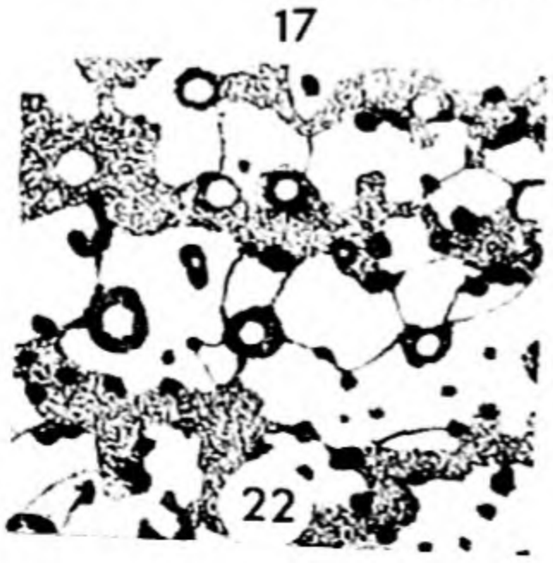
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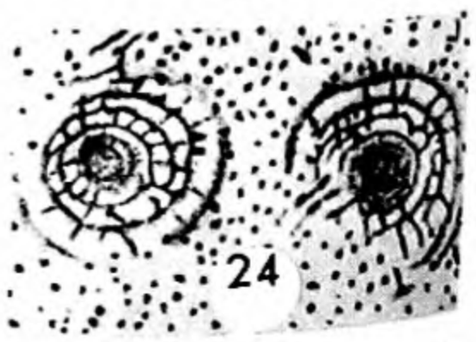
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superficial terminations of concentrically laminated, parallel cylinders that are more or less enveloped by laminae concentric with the entire colony; in having small perforated tubercles at regular intervals in diagonal lines; and in having astrorhizae. **M.** and **U. Sil.:** Ont. (Guelph); N. Y. (Cobleskill), Great Lakes region, Mich. (Monroan).

C. cellulosum Nicholson and Murie (**18**—19, 20). Differs from *C. vesiculosum* in its coarser meshwork (about two laminae in 1 mm), and in having surface tuberculate or granulose; and from *C. striatellum* in its coarser meshwork. **M. Dev.** (Onondaga): Canada; N. Y.

C. laxum Nicholson (**18**—15). **M. Dev.** (Onondaga): Ont.; Ohio (Columbus).

STYLODICTYON Nicholson and Murie 1878

(**S. columnare*). Coenosteum a dense tissue traversed by numerous closely set circular vertical columns of large size, formed by the upward bending of concentric laminae which terminate at the surface in small pointed eminences; tissue more open between columns and consisting of horizontal laminae and radial pillars (often imperfect). Range and distribution below.

***S. columnare** N and M (**18**—23, 24). **M. Dev.:** Mich. (Traverse), Ohio, Ky.

STROMATOPORELLA Nicholson 1886

(**S. granulata*). Coenosteum usually a laminar expansion with basal epitheca; transverse section shows clearly distinguishable laminae and radial pillars, and tangential section shows ends of pillars; laminae with cell-like openings and inflected into hollow points; tissue reticulate. **Sil., Dev.** (distribution below).

***S. granulata** Nicholson (**18**—16). Large (thickness 2 to 3 cm); attached by peduncle and with rest of base covered by concentrically wrinkled epitheca; surface with mamelons, astrorhizae, and closely set tubercles; larger tubercles with apertures at their apices. **M. Dev.** (Hamilton): Ont.; Mich.

S. tuberculata Nicholson and Murie (**18**—21, 22). Differs from preceding in lacking mamelons, with surface undulating and covered only with tubercles of two sizes, and in coarser meshwork (about six laminae in 2 mm). **M. Dev.** (Onondaga): Canada; N. Y.

STROMATOPORA Goldfuss 1826

(**S. concentrica*). Coenosteum massive, hemispheroidal or irregular, and as much as half a meter in diameter; laminae grouped into latilaminae; radial pillars numerous, extending across a stratum and uniting with the laminae to form finely reticulated tissue as seen in transverse section; mamelons and astrorhizae commonly present; this has long been a "form genus" and many stromatoporoids have been incorrectly identified as the genotype. **Sil., Dev.** (E. Canada; N. Y., N. J., Pa., Md., W. Va., Ind.; England).

S. antiqua Nicholson and Murie (**19**—1, 2). Latilaminae well developed, averaging five or six in 1 cm; astrorhizal centers 4 to 5 mm apart; mamelons apparently lacking. **Niagaran:** Hudson Bay region; Ont.; N. Y., Ind. (Liston Creek).

S. constellata Hall (**S. concentrica** of many authors) (**19**—5). Coenostea large, hemispheroidal, with well-developed latilaminae, often reef builders; radial pillars and concentric laminae intimately fused, with both averaging about seven in 1 mm. **Sil.** (Niagaran-Cayugan): Hudson Bay region; Que. (West Point); N. Y., Ind. (Liston Creek). **L. Dev.** (Helderberg): N. J., Pa., Md., W. Va.

SYRINGOSTROMA Nicholson 1875

(**S. densum*). Differs from *Stromatopora* in its denser structure and thinner laminae. **Sil. Dev.** (Ont.; N. Y., Md., Mich.).

S. niagarense Parks (**19**—9, 10). Coenosteum circular, explanate, with diameter of about 8 cm and thickness in center of 15 mm; latilaminae well developed, each layer 2 to 4 mm thick; surface smooth and undulating; large vertical pillars continuous through successive laminae but not through entire coenosteum. **Niagaran:** Great Lakes region.

S. barretti Girty (**19**—3, 4). Coenosteum hemispheroidal with flat base; surface without mamelons and astrorhizae; laminae flexed in wavelike undulations. **L. Dev.** (Helderberg): N. Y., Md.

BEATRICIDAE. Raymond (1931, 184) included in this family "sessile hydromedusae with simple or branched calcareous skeleton consisting of a camerate tube which may be surrounded by cystose or by cystose and radially arranged tissue." The coenosteal surface is typically nodose, or ribbed longitudinally. The following genera are included in the family: *Beatricea* Billings; *Aulacera* Plummer; *Thamnobeatricea*, *Cladophragmus*, and *Cryptophragmus*, all erected by Raymond.

PLATE 18

[Figures are x10 and after Parks [U Toronto Stud, gs 4, 5, 39] unless otherwise indicated.]

1–3. Millepora spp. [Twenhofel and Shrock (after Nicholson and Lydekker) "Invertebrate Paleontology," by permission of McGraw-Hill Book Co., Inc.]. A nearly complete colony (x1), and longitudinal and tangential sections considerably enlarged. **4–7. Actinostroma spp. 4–6. A. tenuifilatum.** Vertical sections showing coarse and finer structure, and tangential section. **7. A. expansum.** Vertical section. **8, 9. Anostylostroma hamiltonense.** Vertical and tangential sections. **10, 11. Trupetostroma warreni.** Vertical and tangential sections. **12–15, 17–20. Clathrodictyon spp. 12. C. vesiculosum.** Vertical section. **13. C. vesiculosum minutum.** Vertical section. **14. C. cystosum.** Vertical section. **15. C. laxum.** Vertical section. **17, 18. C. striatellum.** Vertical and tangential sections. **19, 20. C. cellulosum.** Weathered fragment and vertical section [Nicholson: Mon British Stromatoporoids]. **16, 21, 22. Stromatoporella spp. 16. S. granulata.** Vertical section. **21, 22. S. tuberculata.** Vertical and tangential sections. **23, 24. Stylodictyon columnare.** Vertical and tangential sections.

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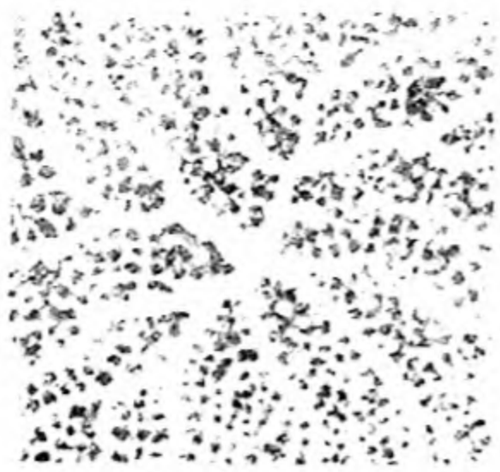

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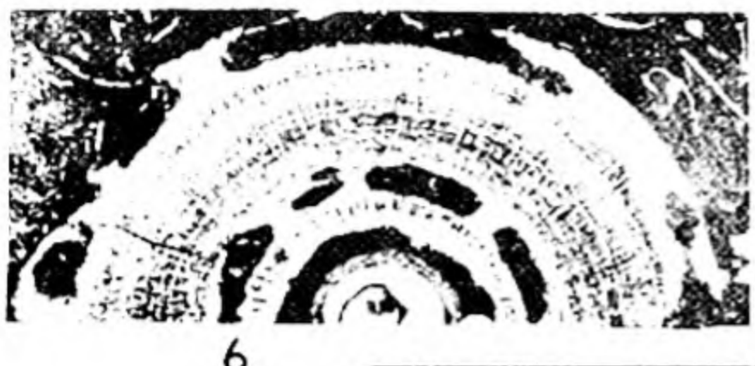

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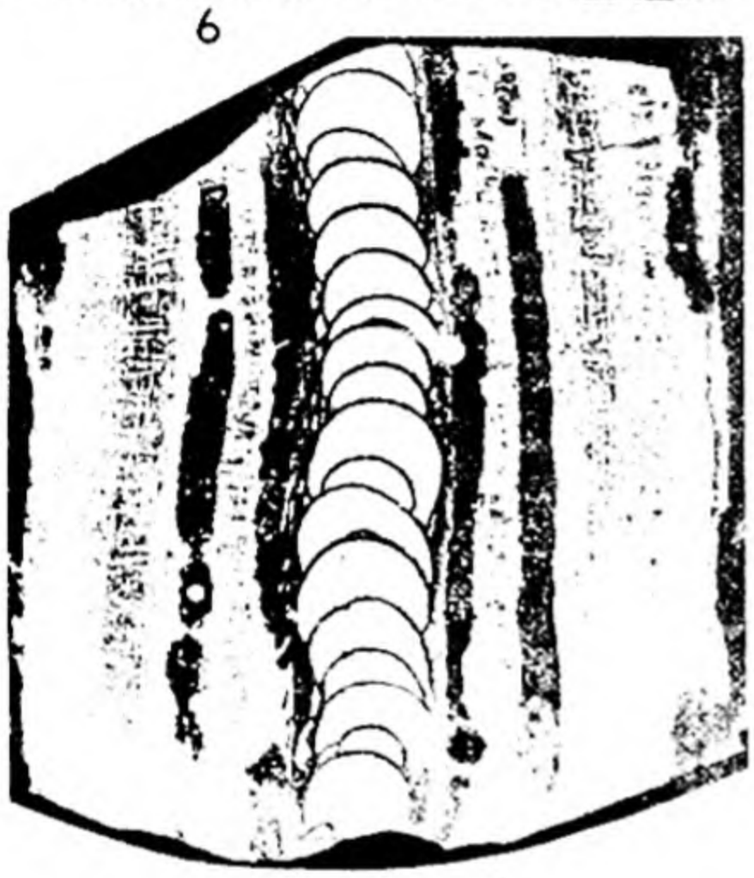

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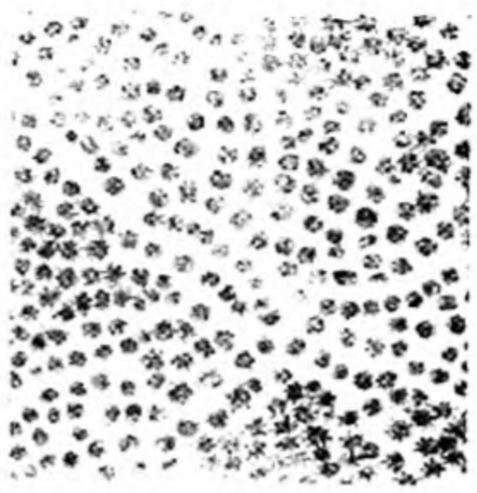

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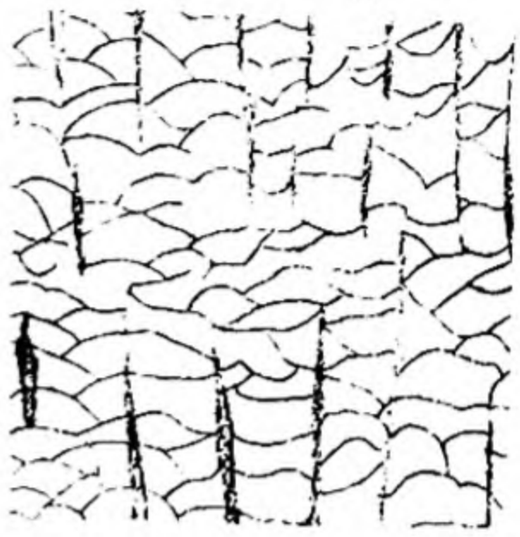

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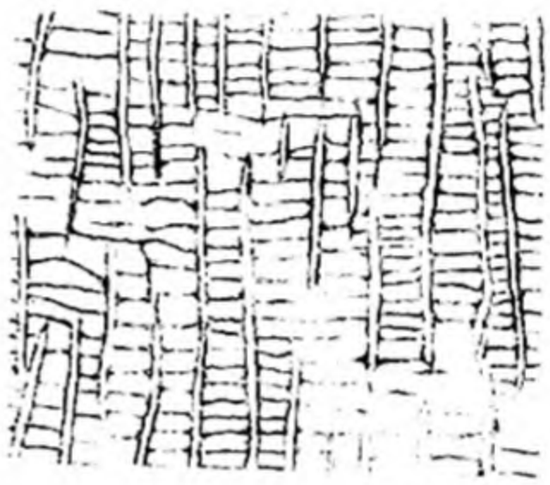

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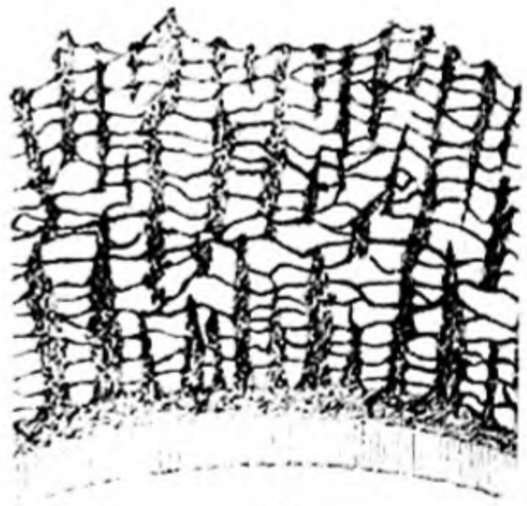

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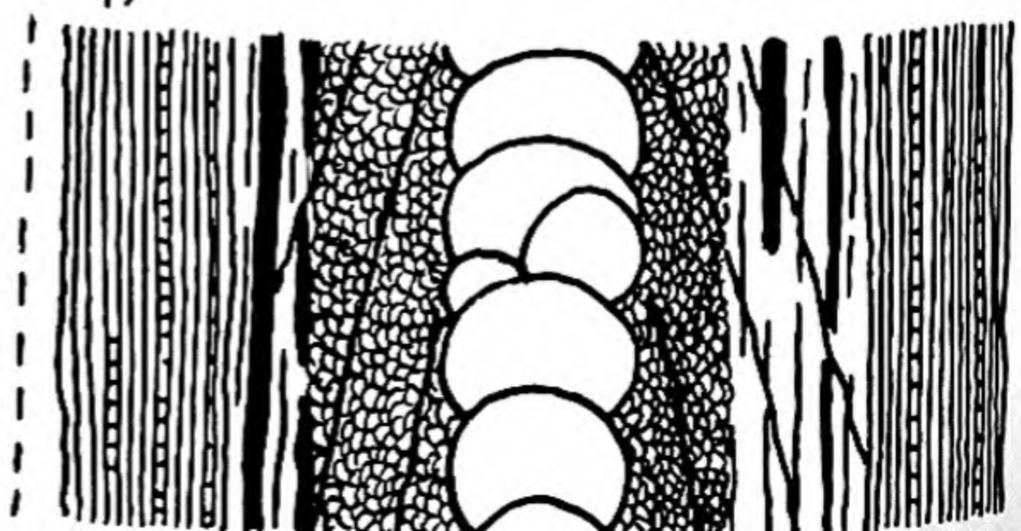

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BEATRICEA Billings 1857

(**B. nodulosa*). Coenosteum cylindrical, unbranched and calcareous; consisting of a large camerate axial tube surrounded by cystose tissue, often highly developed, and in some species containing radial pillars. **Ord.** (Anticosti; Que.; Pa., Ohio, Ind., Ky., Tenn.; Man.).

***B. nodulosa** Billings (**19**—17, 18). Cylindrical, with oblong, oval or subtriangular pointed tubercles, sometimes arranged in vertical rows. **U. Ord.:** Anticosti (Vauréal, Ellis Bay); Ohio, Ind., Ky.; Man.

B. gracilis Foerste. Stems 6 to 12 mm in diameter and several centimeters long; surface granules connected by more or less anastomosing lines; axial tube with strongly convex tabulae or lamellae which occupy almost the entire width of the stem. **M. Ord.:** Pa. and Tenn. (Stones River), Ky. (Tyrone).

AULACERA Plummer 1843

(**Beatricea undulata* Billings). Like *Beatricea*, but with surface sulcated longitudinally and apparently without radial pillars. Range and distribution below.

***A. undulata** (Billings) (**19**—16, 19, 20). **U. Ord.:** Akpatok Island, Ungava Bay, NWT; Anticosti (Vauréal, Ellis Bay); Que., Ont.; Ohio, Ind., Ky.; Man.

THAMNOBEATRICEA Raymond 1931

(**T. parallela*). Like *Beatricea*, but with branching habit, small development of cystose tissue, and apparently without radial pillars. **M. Ord.:** Pa.

CRYPTOPHRAGMUS Raymond 1914

(**C. antiquatus*). Coenosteum an upright, elongate, unbranched, cylindrical skeleton consisting of a camerate axial tube with distinct wall, surrounded by cystose tissue, the sheaths of which are perforated by circular openings disposed at right angles to the coenostial axis. Range and distribution below.

***C. antiquatus** Raymond (**19**—6–8). **M. Ord.:** Que., Ont.; N. Y. (Pamelia), Pa. (Lowville, Stones River), Va. (Lowville), Ind. (Black River), Ala. (Chickamauga).

INCERTAE SEDIS. This group of fossils of uncertain systematic position contains several genera that usually are included in the **Stromatoporoidea,** although such reference has often been questioned. Two families, not necessarily closely related, are for the present included in this artificial and unsatisfactory division. All genera exhibit some characteristics that ally them with coelenterates in general.

The families are LABECHIIDAE, including *Labechia* Edwards and Haime, *Rosenella* Nicholson, *Amphipora* Schulze, and *Stromatocerium* Hall; and IDIOSTROMIDAE, including *Stachyodes* Bargatzky and *Idiostroma* Winchell. Only *Labechia* and *Stromatocerium* deserve mention as index fossils.

STROMATOCERIUM Hall 1847

(**S. rugosum*). Coenosteum consisting of superimposed series of laminae which may be fairly straight and continuous or flexed with convexities upward so as to be reduced to a mass of superimposed vesicles; laminar tissue transected by numerous bent and angulated plates of variable horizontal extent, which may be arranged around certain points, thereby simulating astrorhizae of true stromatoporoids. **Ord.** (E. Canada; widespread in U. S. A.).

***S. rugosum** Hall (**19**—12, 13). Coenosteum hemispheroidal, as much as 20 cm in diameter, with wrinkled concentric laminae (seven in 1 mm), and with faint indications of vertical skeletal elements which may degenerate into vesicular tissue accompanied by failure of vertical elements. **Black River:** Que.; N. Y., Ky. to Ala.

S. huronense (Billings) (**19**—11). Like preceding, but surface with mamelons and tiny tubercles; radial pillars distant and interstitial spaces vesicular. **Cincinnatian:** Ont.; Ohio, Ind., Ky., Tenn., N. Mex.

LABECHIA Edwards and Haime 1851

(**Monticularia conferta* Lonsdale). Incrusting expansions with basal epitheca; vertical pillars a series of blunt tubercles in young; connected in adult by thin calcareous plates; surface mamellose. **Ord., Sil.** (Ont.; Mich., Ohio, Ind.).

L. subcylindrica (James) (**19**—14, 15). **U. Ord.:** Ohio (Waynesville).

PLATE 19

[Figures are x10 and after Parks [U Toronto Stud, gs 5, 7] unless otherwise indicated.]

1, 2. Stromatopora antiqua. Vertical and tangential sections. **3, 4. Syringostroma barretti** [N Y St Mus, An Rp 48 (2)]. Tangential and vertical sections. **5. Stromatopora constellata.** Vertical section. **6–8. Cryptophragmus antiquatus** [CGS, Mus B 5]. Transverse and longitudinal sections of entire colony, and natural longitudinal section of the camerate axial tube (all x1). **9, 10. Syringostroma niagarense.** Vertical and tangential sections. **11–13. Stromatocerium** spp. **11. S. huronense.** Vertical section. **12, 13. S. rugosum.** Vertical and tangential sections. **14, 15. Labechia subcylindrica.** Incomplete colony (x1) and vertical section. **16, 19, 20. Aulacera undulata** (x1). 16: An incomplete colony showing prominent angular longitudinal ridges [photograph by F. M. Carpenter]. 19, 20: Diagrammatic transverse and longitudinal sections showing characteristic internal structure; central camerate tube usually somewhat smaller [Original by R. R. Shrock]. **17, 18. Beatricea nodulosa** (x1) [photographs by F. M. Carpenter]. Surface showing nodose character, and longitudinal section showing large camerate axial tube.

CLASS GRAPTOZOA[1]

Extinct, exclusively colonial and marine organisms which secreted a supporting and protective exoskeleton of chitinous material; each individual lived in a small cup (*theca*) or pit along a chitinous stalk; exoskeleton usually fossilized as carbonaceous films resembling threads or tiny saw blades; class represented by many widespread index fossils. **U. Camb.–L. Miss.**

All graptolite colonies arise by serial budding from a primary or embryonic cup, the *sicula*, built by the first individual. From near the apertural part of the sicula springs the primary bud, and this in turn immediately produces one or two secondary buds. Thereafter, additional buds develop from those already in existence. The number of buds, and their arrangement with respect to the sicula and axis of the colony, determine the architecture of the entire exoskeleton, which is designated a *rhabdosome* if a simple colony or *synrhabdosome* if compound. Individual branches of the former are called *stipes*, and these often resemble tiny saw blades. Stipes with thecae in a single row are uniserial (*Monograptus*); those with thecae in two rows on opposite sides of the median line are biserial (*Diplograptus*); those with four rows, arranged symmetrically about the axis, are quadriserial (*Phyllograptus*). In the **Axonophora** the stipes are reinforced by a median axis or rod, the *virgula*, which extends the entire length of the stipe and beyond the last formed theca; the **Axonolipa** lack a virgula.

Thecae may be strung out along a branch, if

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[1] **Ami, H. M.,** Cambrian age of *Dictyonema* slates of New Canaan and Kentville: *N. S. G Mag* 9: 218–220, il, 1902; *N S Inst Sci*, Pr Tr 10 or (2) 3: 447–450, 1903. **Bassler, R. S.,** Dendroid graptolites of Niagaran dolomites at Hamilton, Ontario: *USNM*, B 65: 1–76, il, 1909. **Bulman, O. M. B.,** Monograph of British dendroid graptolites: *Palaeontogr Soc London*, pts 1–3, il, 1927–1934; Graptolithina in **O. H. Schindewolf's** Handbuch der Paläozoologie, Verlag von Gebruder Borntraeger, B 2D, Lief 2: 1–92, il, 1938. **Burling, L. D.,** Graptolite localities of western North America [Abst]: *GSA*, B 32: 127–128, 1921. **Clark, T. H.,** Graptolites of Glenogle formation: *Can Field Nat* 40: 136–137, 1926; A new Ordovician graptolite locality in Utah: *JP* 9: 239–246, 1935. **Cox, I. H.,** *Climacograptus inuti* and its development: *G Mag* 70: 1–19, 1933. **Decker, C. 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B.: *N Y Ac Sc*, An 22: 135–160, il, 1912. **Hall, J.,** On graptolites, their duration in geological periods, and their value in the identification of strata: *Am As*, Pr 2: 351–352, 1850; Notes on *Graptolithus*. *N Y St Cab*, An Rp 12: 45–58, 1859; Graptolites of the Quebec Group: *CGS, COR*, d 3: 1–151, il, 1865; *Can Nat* ns 2: 42–53, 1865; Introduction to the study of the Graptolitidae: *N Y St Cab*, An Rp 20: 169–240, il, 1867. **Johnson, J. H.,** Discovery of graptolites in Colorado [Abst]: *GSA*, Pr 1934: 354, 1935. **Marr, J. E.,** The Stockdale shales of the Lake District: *GSL*, QJ 81: 113–133, il, 1925. **Matthew, G. F.,** Cambrian graptolites: *N Y Ac Sc*, Tr 14: 262–273, il, 1895. **McCrady, J.,** On the zoological affinities of graptolites: *Elliot Soc N H Charleston*, Pr 1: 229–236, 1859. **McLearn, F. H.,** The lower Ordovician (*Tetragraptus* zone) at St. John, N. B., and the new genus *Protistograptus: AJS* (4) 40: 49–59, 1915. **Miser, H. D.,** and **Purdue, A. 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each succeeding theca buds from near the margin of the preceding; in many genera, however, they bud so rapidly as to overlap the preceding, from less than one-fourth to almost the entire length. In the former instance the apertural serrations are far apart; in the latter, which is more specialized, they are close together.

Rhabdosomes differ widely in architecture. They may consist of: a single uniserial (*Monograptus*) or biserial (*Climacograptus*) stipe; two uniserial branches almost completely free (*Didymograptus*) or free distally but coalescent proximally (sicular end) (*Dicranograpius*); four uniserial branches attached only in the proximal region (*Tetragraptus*); numerous uniserial branches attached in various ways (*Nemagraptus*); or shrublike structures with unithecal, bithecal, or pitted branches bound together by crossbars (*dissepiments*) as in the **Dendroidea** (*Dictyonema*).

Rhabdosomes may be united by the distal ends of the virgulae, forming a synrhabdosome which in some cases is provided with a float or bladderlike structure (e.g. *Glossograptus* (22—13)). Some graptolites apparently were planktonic, and others, like modern hydroids, were probably attached to seaweeds. Since seaweeds, when torn from their anchorage, commonly float for long distances, it may be that they were largely responsible for the wide distribution of graptolites and their presence in rocks of essentially the same age in widely separated parts of the world.

Graptolites are well preserved in fine siltstones and claystones, especially black shale, but are best preserved in limestones. They also occur rarely in sandstones. They are excellent index fossils of the Upper Cambrian, Ordovician, and Silurian for both intra- and inter-continental correlation.

Graptozoa, more commonly called graptolites, are subdivided into two orders: **Dendroidea** and **Graptoloidea.** The more important genera of each order follow.

Order Dendroidea. Mostly sessile benthonic forms with shrublike rhabdosomes. **U. Camb.–L. Miss.**

DICTYONEMA Hall 1851

(**Gorgonia? retiformis*). Rhabdosome fanlike or funnel-shaped; composed of bifurcating branches arising from an acute base and united at intervals by dissepiments; thecae appear as serrations in side view, or as pits on the side of the branches turned toward the inside of the funnel. **U. Camb.–L. Miss.** (widespread throughout Canada, U. S. A., and the rest of the world; probably the commonest of all graptolite genera).

D. minnesotense Ruedemann (20—1). Rhabdosome small; branches 8 to 10 in 10 mm, fairly straight, narrow (0.55 mm), and separated by intervals equal to double width; dissepiments rare and chiefly in basal portion; thecae slightly projecting, about 16 in 10 mm. **U. Camb.:** Minn. (Trempealeau), Okla. (L. Arbuckle).

D. flabelliforme (Eichwald) (20–-6). Rapidly expanding cones up to 30 cm (10 to 12 in.) long; branches about 0.4 mm wide, subparallel, rigid, bifurcating at long intervals and separated by a little over 1 mm; dissepiments about half as thick as branches. **L. Ord.:** Newf. (Green Point); eastern N. America; widespread in northern Europe.

D. flabelliforme anglica Bulman (20—3). **L. Ord.:** N. S.; N. Y.; B. C. (Cushina).

D. crassibasale Gurley (20-–2). Flat, saucer-shaped rhabdosome, with broadly conical central portion and diameter as great as 0.5 m; branches fairly thick (0.5 to 0.6 mm), parallel, close together (10 to 12 in 10 mm), and bound by numerous dissepiments; meshwork somewhat irregular where branches bifurcate; thecae indicated by oval elevations, frequently well preserved, 20 to 25 in 10 mm. **M. Sil.:** Ont.; N. Y. (Lockport), Ind. (Mississinewa).

***D. retiforme** (Hall) (20—12). Broadly funnel-shaped; branches rather coarse, frequently bifurcating, marked externally by flexuous striae, diameter of dissepiments about a fourth that of branches; dissepiments oblique and numerous. **M. Sil.:** Ont.; N. Y. (Rochester).

D. crassum Girty (20—11). Differs from following in its thicker branches and more closely spaced dissepiments. **L. Dev.:** N. Y. (New Scotland).

D. hamiltoniae Hall (20-–13). Branches slender, bifurcating, somewhat flexuous and uniting as in *Desmograptus* (to which genus this species may belong); dissepiments scattered. **M. Dev.:** N. Y. (Hamilton), Mich.

CALLOGRAPTUS Hall 1865

(**C. elegans*). Rhabdosome fanlike or funnel-shaped; branches straight or gently flexuous, 0.5 to 1.0 mm wide and regularly bifurcating; dissepiments rare; thecae on one side, free and projecting. **U. Camb.–Sil., ?Miss.** (Newf.; N. B., Que., Ont.; N. Y., Ind., Wis., Minn., Okla.; Wales; Europe; Asia; ?Australia).

C. staufferi Ruedemann (20—4, 5). Rhabdosome fairly small (38 mm long, 25 mm wide); branches about 0.5 mm wide, bifurcating at intervals of 2 to 5 mm, subparallel and about 10 in 10 mm; dissepiments rare; thecae projecting 1 mm at 50°, overlapping a third their length, 12 to 14 in 10 mm. **U. Camb.:** Wis. and Minn. (Trempealeau), Okla. (L. Arbuckle).

DENDROGRAPTUS Hall 1858

(**Graptolithus hallianus* Prout). Rhabdosome with strong main stem supporting broad, spreading shrublike frond; thecae well marked. **U. Camb.–U. Sil.** (Que., Ont.; N. Y., Ind., Wis., Okla., Nev.: Wales; S. America).

***D. hallianus** (Prout) (20—15, 16). Rhabdosome bushy or arborescent; branches with wavy, slightly flexuous appearance; main branches arranged serially on the stipe and bifurcating, 0.5 mm wide and of

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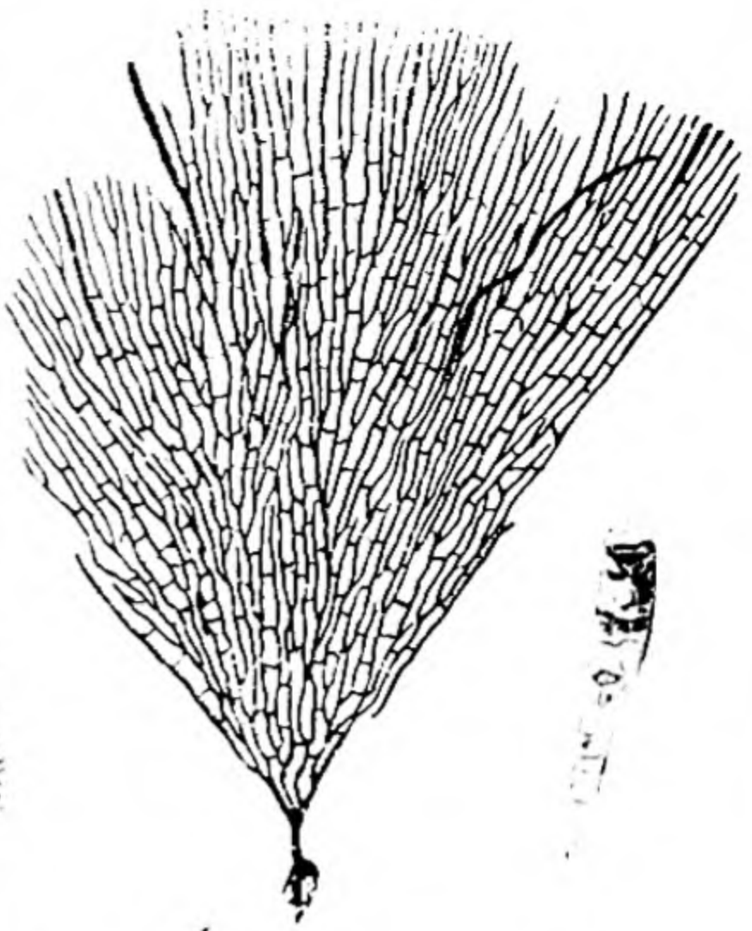

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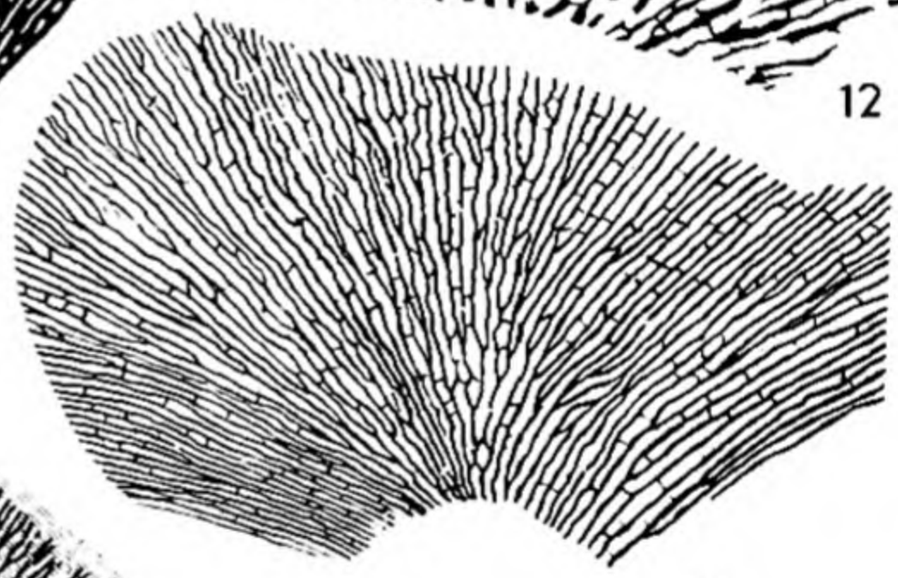

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uniform thickness; thecae slender, distinctly projecting, overlapping half their length, 13 to 15 in 10 mm; as a rule turned in one direction. **U. Camb.:** Wis. and Minn. (Trempealeau), Okla. (L. Arbuckle).

D. edwardsi Ruedemann. Differs from the preceding, with which it occurs, in its coarser structure and composition; branches 1 mm wide and thecae 8 to 11 in 10 mm.

D. flexuosus Hall (**20**—19). Length 25 mm or more; branches broadly and rather regularly diverging. **L. Ord.:** Que. (Levis); N. Y. (Deepkill); Wales (Arenig).

DESMOGRAPTUS Hopkinson 1875

(**Dictyograptus cancellatus* Hopkinson). Differs from *Dictyonema* in the flexuous character of the branches which coalesce at intervals; dissepiments chiefly in lower part of rhabdosome. **Ord.–Dev.** (Que.; N. Y., Ind., Ky., Wis.; Wales).

***D. cancellatus** (Hopkinson) (**20**—14). Branches 12 to 14 in 10 mm, forming long, narrow meshes twice as long as wide; thecal apertures circular. **L. Ord.:** Que. (Levis); N. Y. (Deepkill); Wales (Arenig).

D. micronematodes (Spencer) (**20**—17, 18). Rhabdosome cyathiform, with anastomosing appearance due to irregular rhomboidal interstices between branches; branches delicate, 0.25 mm wide, 1 to 2 mm between points of anastomosis, usually terminating in two or three points; dissepiments apparently absent. **M. Sil.:** Ont.; N. Y. (Lockport), Ind. (Mississinewa), Wis.

D. cadens (Hall) (**20**—21). Coarser than *D. cancellatus*, with thicker branches (about 1 mm wide) and irregular, generally quadrangular meshes. **M. Dev.:** N. Y. (Hamilton).

MARSIPOGRAPTUS Ruedemann 1936

(**M. bullatus*). Structure like *Desmograptus*; branches bear attached hemispheroidal chitinous swellings considered homologous to the ovicells of bryozoans. Range and distribution below.

***M. bullatus** Ruedemann. **L. Ord.:** Tenn. (Ottosee).

M. percensis Ruedemann (**20**—23). **U. Ord.:** Que. (Whitehead).

ACANTHOGRAPTUS Spencer 1878

(**A. granti*). Rhabdosome shrublike, consisting of thick serrated branches mainly rising from base, with little divergence and occasional bifurcation; one side of branches furnished with prominent spines which apparently mark thecal apertures. **U. Camb.–Sil.** (**A. walkeri** (Spencer) has been reported from the **Niagaran** of Ont., N. Y. (Lockport, Rochester), and Ind. (Mississinewa); Europe; Asia).

***A. granti** Spencer (**20**—24). **Niagaran:** Ont.

THALLOGRAPTUS Ruedemann 1925

(**Dendrograptus? succulentus*). Rhabdosome dendroidal, with broad, thick branches; thecal apertures appear as pores on general rhabdosome surface. **M. Sil.:** (Ont.; N. Y., Ind.).

T. phycoides (Spencer) (**20**—20). Stem flattened, with width of 2 to 3 mm; branches forming a conical bundle and originating on both sides of principal stipe at frequent but irregular intervals, and bifurcating near their terminations into branchlets 0.75 to 1.5 cm long, which end in dichotomous free points; thecal apertures appear as minute pores on finely lineated or smooth surface of branches. **Niagaran:** Ont.; N. Y. (Lockport), Ind. (Mississinewa).

INOCAULIS Hall 1851

(**I. plumulosa*). Rhabdosome composed of broad (3 mm) free branches which divide dichotomously at irregular intervals, and form an arborescent structure; rhabdosome large, with length as great as 14 cm and width 17 cm. **Sil.** (Anticosti; Ont.; N. Y., Ind.).

***I. plumulosus** Hall (**20**—9). Branches flattened, dichotomous, forming initial angles of 50° to 60° but later becoming subparallel, averaging 3 mm wide; branches thickly set with short tubular processes which project about 1 mm from the body of the branch and number 14 in 10 mm. **M. Sil.:** Ont.; N. Y. (Lockport).

I. ramulosus Spencer (**20**—10). Rhabdosome consisting of numerous flattened, bifurcating branches originating in and radiating from a common stem; branches 2 mm wide for larger, 1 mm for smaller; differs from preceding in having more slender branches which rise regularly and more abundantly from sides of main stipes. **Niagaran:** Ont.; N. Y. (Lockport), Ind. (Mississinewa).

PTILOGRAPTUS Hall 1865

(**P. plumosus*). Branches of rhabdosome provided with two rows of alternate branchlets; no traces of

PLATE 20

[Figures are x1 and after Ruedemann [N Y St Mus, M 7, 11; PMCM, B 12 = Public Museum City of Milwaukee, Bulletin] unless otherwise indicated.]

1–3. Dictyonema spp. **1. D. minnesotense. 2. D. crassibasale** [USNM, B 65]. **3. D. flabelliforme anglica** (x3.3) [AJS (5) 20]. **4, 5. Callograptus staufferi.** A fairly complete rhabdosome, and a few branches enlarged (x4). **6. Dictyonema flabelliforme** [N Y Ac Sc, Tr 14]. **7, 8. Haplograptus wisconsinensis** (x4). A colony and a single tube. **9, 10. Inocaulis** spp. **9. I. plumulosus.** Part of a large specimen showing coarse structure. **10. I. ramulosus** [N Y St Mus, B 265]. **11–13. Dictyonema** spp. **11. D. crassum. 12. D. retiforme. 13. D. hamiltoniae. 14. Desmograptus cancellatus. 15, 16. Dendrograptus hallianus.** A small fragment considerably enlarged (x4) and an incomplete rhabdosome. **17, 18. Desmograptus micronematodes** [USNM, B 65]. An incomplete rhabdosome, and a fragment much enlarged. **19. Dendrograptus flexuosus** [CGS, COR, d 2]. **20. Thallograptus phycoides** [USNM, B 65]. **21. Desmograptus cadens. 22. Ptilograptus plumosus** (x2) [CGS, COR, d 2]. **23. Marsipograptus percensis** (x6) [JP 10]. **24. Acanthograptus granti** [USNM, B 65].

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thecal apertures known. **Ord., Sil.** (Newf.; Que., Ont.: N. Y.; Europe).

***P. plumosus** Hall (**20–22**). Branchlets slender, threadlike, closely set; diverging at about 40° and about 3.5 mm long. **L. Ord.:** Newf.; Que. (Levis); N. Y. (Deepkill).

HAPLOGRAPTUS Ruedemann 1933

(**H. wisconsinensis*). Single large conical thecae, which by budding, repeated several times, may form primitive irregular stocks; the cone is considered homologous with the sicula of all graptolites and genus is regarded as prototype of all the **Graptoloidea;** *Haplograptus* differs from *Protistograptus* McLearn 1915 [**Cyrtotheca corrugata* Matthew], a genus occurring at a somewhat higher horizon, in showing initiation of a further development into a compound stock by budding. **U. Camb.** (U. S. A.).

***H. wisconsinensis** Ruedemann (**20—7, 8**). First theca originates near aperture of supposed sicula; other thecae originate irregularly near middle of first theca. **U. Camb.:** Wis. (Lodi).

Order Graptoloidea. Mostly planktonic forms with uniserial, biserial, or quadriserial rhabdosomes which may be bound together into synrhabdosomes; rhabdosomes may or may not have a virgula. **Ord., Sil.**

LOGANOGRAPTUS Hall 1868

(**Graptolithus logani*). Rhabdosome consisting of simple branches arising from a single broad axis, this resulting from concentration of dichotomy in proximal region; thecae straight tubes. **Ord.** (distribution below; also S. America).

***L. logani** (Hall) (**21—3**). Numerous (13 to 25, normally 16) slender branches up to 23 cm (9 in.) long, symmetrically branching at base; thecae becoming prominent only at some distance from base; central disk many-angled. **L. Ord.:** N. B. (Bretonian), Que. (Levis); Hudson River valley (Deepkill); England; Australia

DICHOGRAPTUS Salter 1863

(**Dichograpsus aranea* Salter = *Graptolithus octobrachiatus* Hall; [Bulman (1938, D66) lists *Dichograpsus sedgwicki* Salter as the genotype]). Rhabdosome of 8 branches united by a common stem in center, which with the lobes of the branches lies within a central membranous disk; branches with single row of thecae, becoming prominent some distance from center; thecae are straight tubes. **L. Ord.** (distribution below; also S. America and Asia).

***?D. octobrachiatus** (Hall) (**21—4**). Eight large and coarse branches often 30 cm (12 in.) long; central disk eight-angled. L. Ord.: Que. (Levis, Didymograptus zone); N. Y. (Deepkill, Tetragraptus, Didymograptus, and Dipograptus zone); Scandinavia; Belgium; England (Skiddaw); Wales (Arenig); Australia.

STAUROGRAPTUS Emmons 1855

(**Staurograpsus dichotomus*). Rhabdosome crosslike at center owing to rapid budding of early thecae; repeated bifurcations produce numerous branches; thecae long straight tubes but slightly overlapping. **L. Ord.** (N. America; N. W. Europe; Australia).

***S. dichotomus** Emmons (**21—10**). Branches over 40, the result of repeated bifurcation; thecae 11 to 13 in 10 mm, in contact for slightly over a third their length; apertures nearly vertical to axis. **L. Ord.:** Newf. (Green Point); N. B. (Bretonian); N. Y. (Schaghticoke, *Dictyonema flabelliforme* beds).

GONIOGRAPTUS McCoy 1876

(**Didymograpsus thureaui*). Branching into 4 zigzagging principal axes, from the angles of which spring undivided branches at regular intervals; thecae straight tubes. **L. Ord.** (distribution below; also Australia).

G. thureaui postremus Ruedemann (**21—2**). Four nearly rectangular main branches of zigzag outline, with regularly alternating secondary branches. **L. Ord.:** Que. (Levis); Hudson River valley (Deepkill).

BRYOGRAPTUS Lapworth 1880

(**B. kjerulfi* Lapworth non Ruedemann or Matthew). Like *Staurograptus*, but with branches irregular. **L. Ord.** (N. B.; N. Y.; N. W. Europe; Australia).

B. lapworthi Ruedemann (**21—1**). Very slender, delicate and irregularly branching stipes (maximum width 0.5 mm); thecae uniform, regular, 10 in 10 mm, overlapping one-third to one-half their length; apertural margin straight, forming an oblique angle with the branch. **Canadian:** N. Y. (Deepkill, Tetragraptus zone).

TETRAGRAPTUS Salter 1863

(**T. crucialis*; [Bulman (1938, D70) lists *Graptolithus byronoides* Hall = *Fucoides serra* Brongniart

PLATE 21

[Figures are x1 and after Ruedemann [N Y St Mus, M 7, 11] unless otherwise indicated.]

1. Bryograptus lapworthi (x2). 2. Goniograptus thureaui postremus. 3. Loganograptus logani. 4. Dichograptus octobrachiatus. 5. Tetragraptus quadribrachiatus. 6. Tetragraptus similis. 7–9. Phyllograptus spp. [CGS, COR, d 2]. 7. P. angustifolius. 8. P. anna (x3). 9. P. ilicifolius. Transverse section of rhabdosome (x2). 10. Staurograptus dichotomus (x2) [N Y Ac Sc, Tr 14]. 11. Phyllograptus typus [CGS, COR, d 2]. 12–18. Didymograptus spp. 12. D. serratulus. 13. D. patulus. 14. D. nitidus. 15. D. sagitticaulis. 16. D. artus (x4) [Nat Ac Sc, Pr 21]. 17. D. bifidus (x2). 18. D. protobifidus (x4) [photograph furnished by C. E. Decker]. 19–23. Dicellograptus spp. 19, 20. D. mensurans (x5). 21. D. sextans. 22. D gurleyi. 23. D. divaricatus. 24. Leptograptus annectans. 25. Dicranograptus ramosus. 26. Nemagraptus gracilis. 27–29. Corynoides spp. 27. C. gracilis. 28. C. curtus (x5). 29. C. calicularis (x5). 30, 31. Dicellograptus spp. 30. D. complanatus (x5). 31. D. mensurans. 32, 33. Dicranograptus spp. 32. D. nicholsoni. 33. D. spinifer. 34–39. Climacograptus spp. 34. C. typicalis. 35. C. bicornis (x2) [CGS, COR, d 2]. 36. C. ulrichi (x5). 37. C. scharenbergi. 38. C. parvus. 39. C. putillus (x12) [CGS, COR, d 2]

as the genotype]). "Form genus," probably including several genera; typically of four short and broad, uniserial branches with large thecae which are straight tubes; common transverse stem. **Ord.** (Newf.; N. B., Que.; N. Y., Ark.; Bolivia; Bohemia; Sweden; Scania; France; Great Britain; Asia; Australia).

T. quadribrachiatus (Hall) (**21**—5). Like half a *Dichograptus octobrachiatus*; with four long, slender branches with small thecae and a quadrangular central disk. **L. Ord.:** Newf.; Que. (Levis), N. B.; N. Y. (Deepkill, associated with *Didymograptus* and *Diplograptus*), Ark. (Mazarn); Scandinavia; France; Great Britain (Skiddaw); Australia.

T. similis (Hall) (**21**—6). Four short, broad branches with narrow but long thecae mucronate at margin; strong central stem. **L. Ord.:** Que. (Levis); Hudson River valley (Deepkill), Ark. (Mazarn); Europe; Australia.

PHYLLOGRAPTUS Hall 1858

(**P. typus*). Like *Tetragraptus* with four branches grown together, each two back to back, forming a cross in section; generally preserved in flattened form so as to appear as a single leaflike body; thecae curved tubes. **L. Ord.** (Greenland; Newf.; Que.; N. Y., Ark., Utah, Nev.; S. America; Europe; Asia; Australia).

***P. typus** Hall (**21**—11). Broad, oval to lanceolate as appearing on shale, with 10 thecae in 10 mm (22 to 26 per inch); broad axis or midrib, often crenulate or serrate. **Canadian:** Que. (Levis); N. Y. (Deepkill, *Didymograptus bifidus* zone), Ark.; Europe; Australia.

P. angustifolius Hall (**21**—7). Narrow, elongate form, generally slightly broader at base; thecae strongly mucronate on lower sides. **Canadian:** Que. (Levis); N. Y. (Deepkill); Europe.

P. anna Hall (**21**—8). More nearly rounded than preceding, often truncate with numerous thecae. **Canadian:** Que. (Levis); N. Y. (Deepkill), Ark. (Blakely), Okla. (Arbuckle), Tex. (Marathon), Nev.; England (Skiddaw).

P. ilicifolius Hall (**21**—9). Differs from *P. typus* in its thicker substance, proportionately shorter and broader form, and with thecae more closely arranged, 12 in 10 mm (29 to 32 per in.), with strongly mucronate or spinous lower lip. **Canadian:** Que. (Levis); N. Y. (Deepkill); England (Skiddaw).

DIDYMOGRAPTUS McCoy 1851

(**Graptolithus murchisoni* Beck). Rhabdosome consisting of two symmetrical branches diverging from the sicula at angles of 10° to 180° or over; thecae are oblique, straight tubes, opening inward except in angles of 180° or more; probably a "form genus." **Ord.** (Greenland; eastern Canada; N. Y., Tenn., Ark., Okla., Tex., Nev.; Argentina; Great Britain and Europe; Asia; Australia).

D. protobifidus (Elles) (**21**—18). Rhabdosome commonly small, stipes ranging from 1 to 2 cm. in length, narrow at origin and increasing very slightly in width to maximum of 1.3 mm, either running parallel or diverging in the manner of *D. bifidus*; sicula conspicuous, slender; thecae 13 in 10 mm, free for half their length, inclined at a low but variable angle, slightly curved distally, with apertural margins slightly oblique to general direction of stipe. **L. Ord.:** Ark. (Smithville), Okla. (U. Arbuckle), Tex. (Marathon); probably also in Deepkill of N. Y., rather than *D. bifidus* as reported.

D. bifidus (Hall) (**21**—17). Divergence of branches 15° to 20°, gradually widening through increase in length of thecae to about two-thirds distance from base, then narrowing again to apex; many American occurrences referred to this species should probably be referred to *D. protobifidus*. **L. Ord.:** Que. (Levis); N. Y. (Deepkill, though actually probably higher in section), Ark. (Black Rock), Okla. (Joins of L. Simpson), Nev., Utah (Garden City); Great Britain (U. Arenig); Norway; Belgium; France.

D. artus Elles and Wood (**21**—16). **L. Ord.:** Okla. (Joins of L. Simpson).

D. nitidus (Hall) (**21**—14). Thecae closely arranged, with slightly concave margin rectangular to axis of thecae; branches with wide angle (180°±) of divergence. **L. Ord.:** Que. (Levis); N. Y. (Deepkill), Ark. (Mazarn); Argentina; Europe; Australia.

D. patulus (Hall) (**21**—13). Differs from preceding in its wider and more rapidly widening branches, with ends of thecae concave and strongly acute instead of rectangular. **L. Ord.:** Que. (Levis), N. B. (Bretonian); N. Y. (Deepkill).

D. sagitticaulis Gurley (**21**—15). Large, with branches up to 2.9 mm wide; length may have been 2.5 mm or more; divergence of branches about 90°; overlap and inclination of thecae rapidly increasing from early stages; in mature part, 7 thecae in 10 mm and these overlap for half their length; width of thecae about half the length; thecae inclined at angle of 25° and apertures perpendicular to thecal axis. **M. Ord.:** Newf.; Que.; N. Y. (Normanskill), Tenn., Ark. (Womble), Okla. (Stringtown); B. C.

D. serratulus (Hall) (**21**—12). Branches straight, diverging at angle of 140° to 155°; sicula large; thecae with sharp points as in *D. patulus*, but less overlapping; width of branches up to 1 to 2 mm. **M. Ord.:** N. Y. (Normanskill), Ark.; Scotland and Ireland (Glenkiln).

CORYNOIDES Nicholson 1867

(**C. calicularis*). Sicula a short, rapidly expanding cone suspended from the nemacaulus; thecae originating close together by successive buddings and remaining united throughout; number of thecae generally three, often appearing as a single tube in compound forms; apertures spinose. **M. Ord.** (eastern Canada; N. Y., Pa., Md., Va., Ark.; Scandinavia; Scotland; Wales and Ireland).

***C. calicularis** Nicholson (**21**—29). Rhabdosome 6 to 8 mm long, 1 mm wide; consisting of small sicula and three thecae originating close together, forming an angle of 50° with sicula; each aperture furnished

with pair of spines. **M. Ord.:** Eastern Canada; N. Y. (Normanskill), Md., Pa., Va. **Ord.** of Scandinavia, Scotland, and Wales.

C. gracilis Hopkinson (**21**—27). Twice as long and half as wide as preceding. **M. Ord.:** N. Y. (Normanskill), Ark.; Scotland (Hartfell).

C. curtus Lapworth (**21**—28). Thecae with a single spine each. **M. Ord.:** Vt., N. Y. (Trenton); Scotland; Ireland (Hartfell).

LEPTOGRAPTUS Lapworth 1873

(**Graptolithus flaccidus* Hall). Rhabdosome composed of two long, threadlike, bilaterally symmetrical branches; thecae with sigmoid curvature. **Ord.** (Que.; N. Y., Ky., Okla.; England; Australia).

L. annectans (Walcott) (**21**—24). Rhabdosome of medium size; branches long (50 mm), doubly curved, 0.3 to 1.0 mm wide; angle of divergence 270° to 290°; thecae 10 in 10 mm, inclined 15°, overlapping one-half their length. **M. Ord.:** N. Y. and Ohio (Utica), Okla. (Viola).

NEMAGRAPTUS Emmons 1855

(= STEPHANOGRAPTUS Geinitz 1866;
COENOGRAPTUS Hall 1868;
HELICOGRAPSUS Nicholson 1868)

(**Nemagrapsus elegans* Emmons = *Graptolithus gracilis* Hall). Bilaterally symmetrical rhabdosome with main stem (of straight tubular thecae) sigmoid; simple uniserial branches given off from convex sides; sicula lies at center of principal stem. **Ord.** (distribution given below; also Ala.; Asia).

***N. gracilis** (Hall) (**21**—26). Slender stem; branches finely serrate from crowding of thecae. **M. Ord.:** Newf.; Que.; Me., N. Y. (Normanskill), N. J., Tenn., Ark. (Womble), Okla. (Stringtown); Great Britain (Glenkiln); Australia.

DICELLOGRAPTUS Hopkinson 1871

(**Didymograpsus elegans* Carruthers). Rhabdosome bilaterally symmetrical, consisting of two uniserial branches which diverge from the sicula at angles greater than 180° (the sicula being within the angle); thecae with conspicuous sigmoid curvature and open introverted apertures. **Ord.** (Canada; Vt., N. Y., Ala., Ark., Okla., Nev.; Great Britain; Asia; Australia).

D. divaricatus (Hall) (**21**—23). Branches diverging at an angle of 270° until almost horizontal; thecae furnished with introverted apertures. **M. Ord.:** Eastern Canada (Chazy); Hudson River valley (Normanskill), Ark. (Womble, Big Fork), Nev.; Scotland and Wales (Glenkiln); Australia.

D. gurleyi Lapworth (**21**—22). Long, slender branches, at first diverging rectangularly, then twisting, sometimes forming a figure 8; thecae overlapping one fourth their length. **M. Ord.:** N. Y. (Normanskill), Ark. (Womble), Okla. (Viola).

D. mensurans Ruedemann (**21**—19, 20, 31). Broadly U-shaped, at base diverging at an angle of 240°, then curving upward, each branch describing more than half an ellipse; thecae about 10 in 10 mm, long and narrow, overlapping half their length, outer margin subparallel to axis. **M. Ord.:** N. Y. (Normanskill), Ala., Ark. (Womble), Okla. (Bromide of U. Simpson, Stringtown).

D. sextans Hall (**21**—21). Similar to *D. divaricatus*, but with basal spines turned up and outward. **M. Ord.:** Newf.; Vt., Hudson River valley (Normanskill), Ark. (Womble); Sweden; Great Britain (Glenkiln); Australia.

D. complanatus Lapworth (**21**—30). Branches diverging at angles of 240° to 270°, thecae narrow, very oblique, and nonmucronate. **U. Ord.:** Ark. (Polk Creek), Okla. (Sylvan); Scotland and Ireland (U. Hartfell).

DICRANOGRAPTUS Hall 1865

(**Graptolithus ramosus*). Rhabdosome Y-shaped, consisting of two symmetrical branches which are free in the distal part and coalescent in the proximal; thecae as in *Climacograptus*. **Ord.** (eastern Canada; Me., N. Y., Ohio, Ark., Okla., Nev.; S. America; Europe; Asia; Australia).

***D. ramosus** (Hall) (**21**—25). Undivided portion long; incisions between thecae deep; thecae with mucronate points. **M. Ord.:** Newf.; eastern Canada; Me., Hudson River valley (Normanskill), N. J., Ark., Okla.; Great Britain (Glenkiln and Hartfell); Australia.

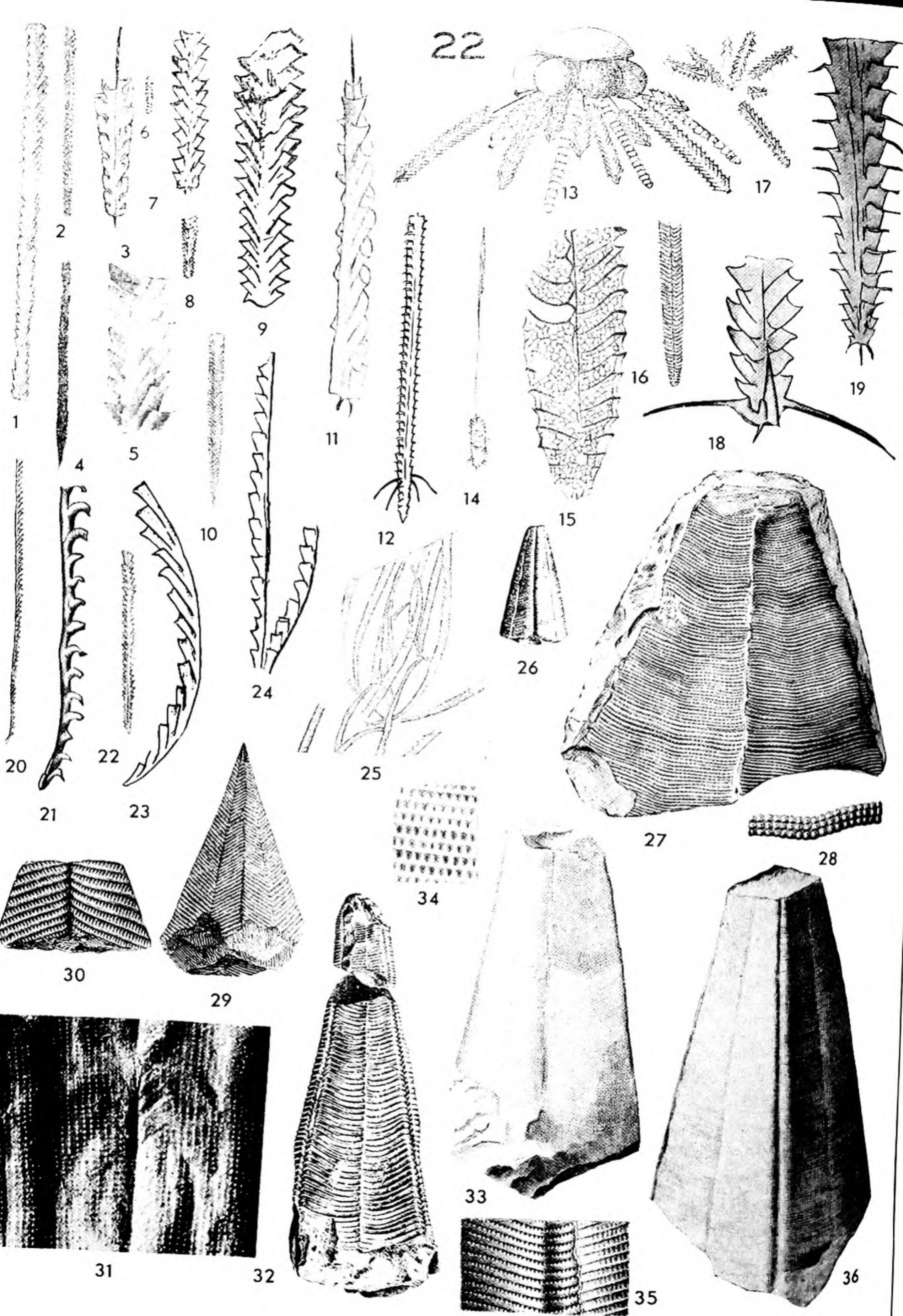
D. nicholsoni Hopkinson (**21**—32). Biserial undivided portion short (4 to 6 mm); uniserial branches long with axial angle of 75° to 80°; thecae with outer walls convex, spinose in biserial part, overlapping about half their length. **M. Ord.:** Me., N. Y. (Trenton–Utica), Cincinnati region, Ark. (Womble), Okla. (Stringtown, Viola); Great Britain (Glenkiln and Hartfell); Australia.

D. spinifer (Lapworth) Elles and Wood (**21**—33). Angle formed by uniserial branches about 40°; branches narrow (1 mm or less); thecae widely arranged (eight to nine in 10 mm) and strongly spinose. **M. Ord.:** N. Y. (Normanskill), Ark. (Womble), Okla. (Stringtown); Great Britain (Glenkiln and Hartfell).

CLIMACOGRAPTUS Hall 1865

(**Graptolithus bicornis*). Simple biserial rhabdosome, bilaterally symmetrical; thecae parallel, their outer margin straight and parallel to rhabdosome axis, tubular; aperture within well-defined excavation. **Ord.** (Greenland; eastern Canada; widely distributed throughout U. S. A.; South America; Europe; northern Africa; Asia; Australia), **Sil.** (rare).

***C. bicornis** (Hall) (**21**—35). Gradually widening upward, thecae approaching rectangular outline; base with two diverging mucronate points. **M. Ord.:** Newf.; Que., N. B.; Hudson River valley (Normanskill), Va., Ala., Ark. (Womble), Okla. (Stringtown, L. Viola); Europe; Great Britain (Glenkiln); Australia.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C. scharenbergi Lapworth (**21**—37). Rhabdosome narrower and thecae more distant than in preceding; sicular spines scarcely developed. **M. Ord.:** Newf.; eastern Canada; N. Y. (Normanskill and later shales), Tenn.; Europe (Arenig? -Caradoc).

C. parvus Hall (**21**—38). Rhabdosome small (average length 20 mm, maximum 32 mm); rapidly attaining full width which is 1.5 to 2.0 mm; sicular extremity spinose; thecae 12 to 15 in 10 mm, overlapping about a third of the length. **M. Ord.:** Newf., Me., N. Y. (Normanskill), N. J., Ark. (Womble), Okla. (Stringtown, Viola).

C. typicalis Hall (**21**—34). Differs from *C. bicornis* in the narrow, almost horizontal incisions between, and small mucronate point at base of thecae. **M. Ord.:** Ont.; N. Y. (Utica), Ohio, Wis. (Galena), Okla. (Viola).

C. putillus Hall (**21**—39). Rhabdosomes very small (9 mm or less long) and narrow (1 to 1.3 mm wide), elliptical in section, widening gradually, and possessing a gently wavy median furrow on each lateral face; thecae tubular, little inclined to axis of rhabdosome in proximal half and subparallel to it in distal free half; closely arranged thecae (12 to 14 in 10 mm); apertures straight and perpendicular to longer axes of thecae; nemacaulus thin. **U. Ord.** (Richmond): Anticosti; eastern Canada; Ill., Wis., Ia., Mo., Ark. (Polk Creek), Okla. (Sylvan).

Ruedemann (1925, 62–63) has divided the Hudson River valley forms usually referred to this species as follows (all species are Ruedemann's): **C.eximius**—U. Normanskill; **C. strictus**—Canajoharie; **C. tenuis** and **C. pygmaeus**—U. Utica; **C. lorrainensis**—Lorraine.

C. ulrichi Ruedemann (**21**—36). Rhabdosome small (12 to 18 mm long, 1.5 mm wide); thecae 10 to 12 in 10 mm. **U. Ord.** (Richmond): Ill., Wis., Ia., Mo., Ark. (Polk Creek), Okla. (Sylvan).

DIPLOGRAPTUS McCoy 1850

(**Graptolithus foliaceus* Murchison; [Bulman (1938, D76) lists *Prionotus pristis* Hisinger as the genotype]). Rhabdosome linear to leaflike, bilaterally symmetrical, with two rows of alternating, oblique, straight, tubular thecae; virgula prolonged beyond the distal end in complete synrhabdosomes attached with others to a central float. **Ord., Sil.** (widespread throughout Canada and U. S. A., almost exclusively in Ordovician strata; S. America; Scandinavia, Great Britain; Asia; ?Australia).

D. (**Orthograptus**) **calcaratus** Lapworth (= **D. foliaceus** and **D. pristis** in part of American authors). (**22**—1). Large, oblique, acute serrations, pointed exteriorly; three basal spines, the central usually longest; thecae forming subprismatic tubes. **Ord.** (this species and its varieties range from Normanskill to Utica): Eastern Canada to Ala., Ark., Okla., Nev.; Europe; Australia.

D. (**Amplexograptus**) **amplexicaulis** (Hall) (**22**—8–10). Rhabdosomes as much as 45 mm long and 4 mm wide; thecae tubular with semicircular section; 13 to 14 in 10 mm, inclined 30° to 40°, overlapping one third. **M. Ord.:** N. Y. (Trenton), Okla. (Viola), Tex. (Maravillas).

D. (**Glyptograptus**) **angustifolius** (Hall) (**22**—22). Rhabdosomes circular in section; thecae 11 to 14 in 10 mm, inclined at 30°, overlapping nearly one third; outer margins concave below, convex above; width of rhabdosome 1.2 to 1.5 mm. **M. Ord.:** Newf.; Que.; N. Y. (Normanskill), N. J., Ark. (Womble), Okla. (Stringtown), Nev.; Rocky Mountains of Canada; Europe.

D. (**Glyptograptus**) **dentatus** (Brongniart) (= **D. pristiniformis** (Hall)) (**22**—4, 5). Narrow, slender stipes with circular section and closely crowded, very oblique thecae. **L. Ord.:** Que. (Levis); Hudson River valley (Deepkill), Ark.; Europe.

D. (**Glyptograptus**) **euglyphus** (Lapworth) (= **D. dentatus** Lapworth) (**22**—2). Rhabdosome circular in section, long and narrow (40 mm long, 1.4 to 2.2 mm wide); nemacaulus thin and long; thecae 7 to 9 in 10 mm (18 to 22 per inch), inclined about 40°; aperture vertical to axis of theca, apertural margin concave; interthecal excavation deep, and as long as free part of theca. **M. Ord.:** Newf.; Que.; N. Y. (Normanskill), Ark. (Womble), Okla. (Stringtown, L. Viola), Nev.; B. C.; Great Britain (Glenkiln).

D. (**Orthograptus**) **nexus** Ruedemann (**22**—3). Rhabdosome strap-shaped, maximum length 12 mm and width 1.5 mm; thecae 13 to 15 in 10 mm, 2 mm long, very straight, overlapping one-half to total length, inclined 30° to 40°, four times as long as wide. **U. Ord.:** Ont.; N. Y. (Eden), Okla. (U. Viola).

D. (**Orthograptus**) **peosta** Hall (**22**—6, 7). Small, of broadly oval section; thecae at angles of 30° to 40°, subrectangular, four times as long as wide, with

PLATE 22

[Figures are x1 unless otherwise indicated; graptolites after Ruedemann [N Y St Mus, M 7, 11]; conularids after Hall [Pal N Y 1, 2, 5].]

1–10. Diplograptus spp. 1. D. calcaratus. 2. D. euglyphus. 3. D. nexus (x5). **4, 5. D. dentatus** (x1, x5). **6, 7. D. peosta** (x1, x4). **8–10. D. amplexicaulis** (x1, x4, x1) [8, 9: JP 8]. **11. Cryptograptus tricornis** (x5). **12–14. Glossograptus spp. 12, 13. G. quadrimucronatus.** A nearly complete rhabdosome; restoration of a complete synrhabdosome showing float and other structures. **14. G. ciliatus.** A complete rhabdosome. **15, 16. Retiolites geinitzianus venosus.** A fragmental rhabdosome, and a much enlarged portion (x6). **17. Lasiograptus mucronatus.** A synrhabdosome showing rhabdosomes of several ages. **18, 19. Glossograptus spp. 18. G. quadrimucronatus cornutus.** Sicular portion much enlarged (x7). **19. G. whitfieldi** (x5). **20, 21, 23, 24. Monograptus spp 20, 21. M. clintonensis** (x1, x5). **23. M. bohemicus** (x4) [JP 9]. **24. M. nilssoni** (x4) [JP 9]. **22. Diplograptus angustifolius. 25. Cyrtograptus ulrichi. 26–30, 32–36. Conularia spp. 26. C. crustula** [Mo G S 5]. **27, 28. C. niagarensis.** A nearly complete specimen, and a small portion considerably enlarged. **29, 30. C. trentonensis.** A nearly complete specimen, and a portion enlarged about twice. **32. C. missouriensis** (x0.5) [Mo G S 5]. **33, 34. C. huntiana.** A nearly complete specimen, and a small portion considerably enlarged to show nature of surface. **35, 36. C. undulata.** A small portion of surface enlarged, and a fairly complete specimen. **31. Metaconularia ulrichi** [DUB, JSL 23]. A small portion of surface, considerably enlarged (x12), showing papillose nature.

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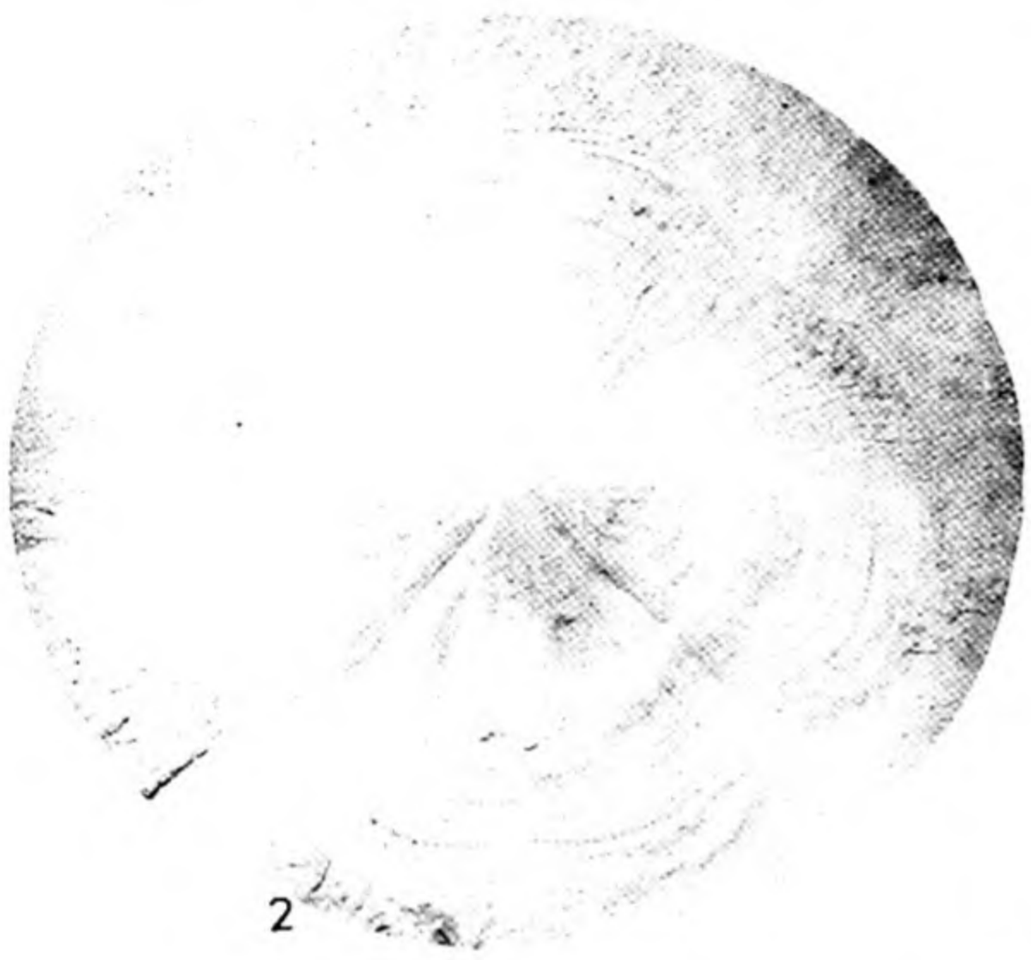
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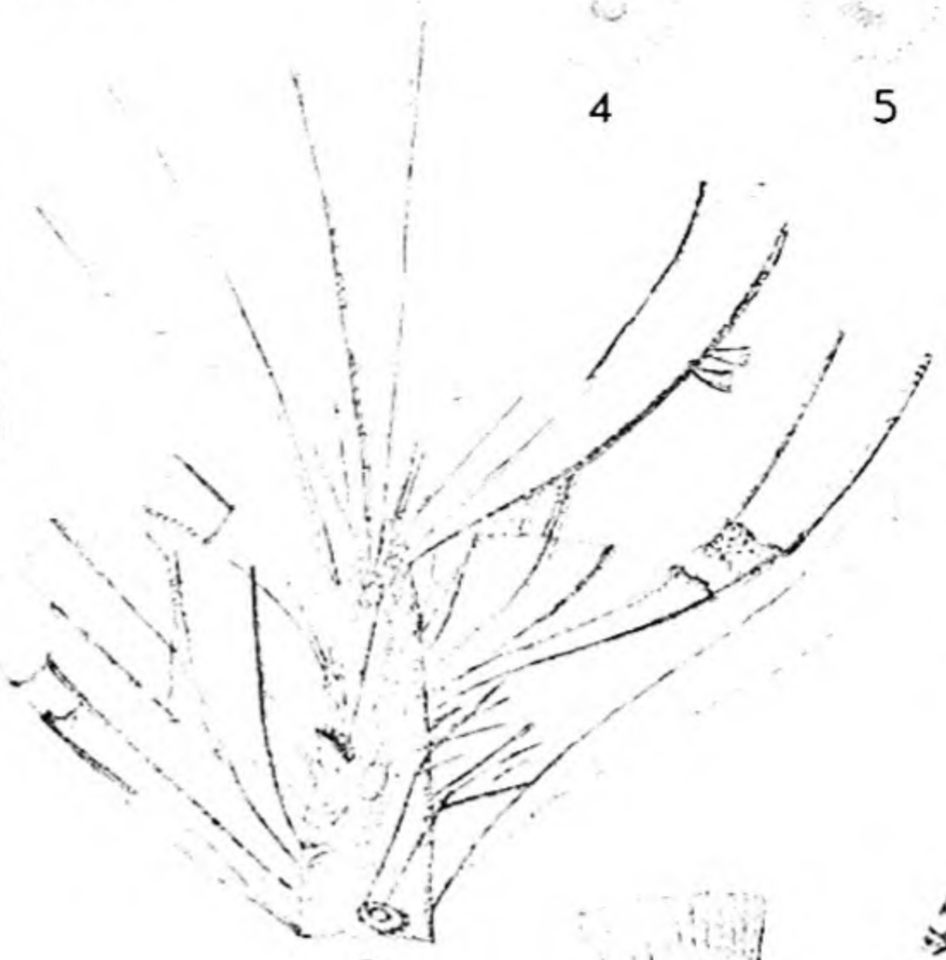
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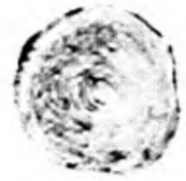
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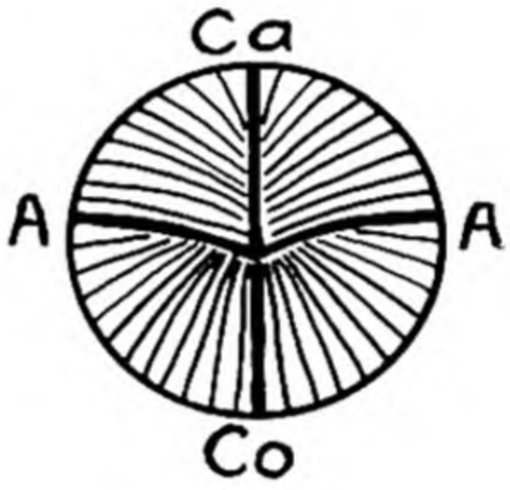

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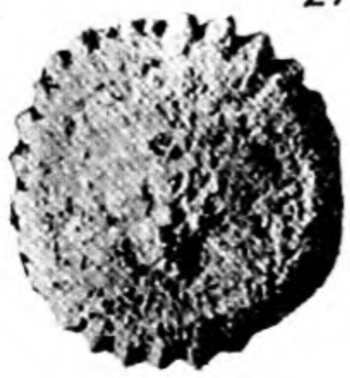
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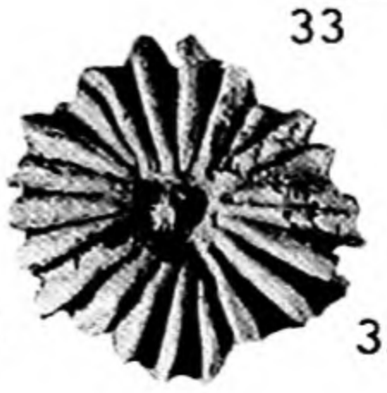
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rounded sides, imbricated on the median line, and overlapping two-thirds their length. **U. Ord.** (Richmond): Wis., Ill., Minn., Ia.

CRYPTOGRAPTUS Lapworth 1880

(**Diplograptus tricornis* Carruthers). Differs from *Diplograptus* and *Climacograptus* in the deep excavations of outer margin of theca; spine at top of theca; chitin thin, thus lacking gloss of thick-tested graptolites. **Ord.** (distribution below).

***C. tricornis** (Carruthers) (**22**—11). Short (25 mm or less) and narrow (1.3 mm) rhabdosome with four spines at sicular end (three generally seen); thecae tubular, inclined 20°, overlapping one-third to one-half, mucronate, often recurving, the appearance at times that of reversed thecae. **M. Ord.:** Newf.; eastern Canada; N. Y. (Normanskill), Tenn., Ark. (Womble), Okla. (Stringtown, Viola), Nev.; S. America; Great Britain (Glenkiln); Bohemia; Asia; Australia.

GLOSSOGRAPTUS Emmons 1855

(**G. ciliatus*). Rhabdosome shaped like long, fairly narrow leaves, ornamented with two rows of isolated spurs; each theca bearing one or two long spines at outer margin of aperture. **Ord.** (Que., B. C.; Me., N. Y., Ala., Cincinnati region, Ark., Okla., Nev.; Bolivia; Europe; Great Britain; Asia; Australia).

***G. ciliatus** Emmons (**22**—14). Rhabdosome prismatic, of subhexagonal section; thecae broad and low, of rectangular section, inclined 30°, overlapping three-fourths; aperture rectangular, two long curved spines springing from middle of horizontal outer lip. **M. Ord.:** Newf.; Que., Ont. (Glenogle); Me., N. Y. (Normanskill), Ala., Ark. (Womble), Okla. (Viola), Idaho, Nev.; Wales.

G. quadrimucronatus (Hall) (= **Diplograptus pristis** in part) (**22**—12, 13). Very closely set, rectangular thecae, overlapping two-thirds their length, with scarcely projecting lips but with two strong spines, one at each lip angle. **M. Ord.:** Que.; N. Y. (Trenton), Cincinnati region, Okla. (L. Viola), Nev.; Europe. **G. quadrimucronatus approximatus** Ruedemann. N. Y. (Utica). **G. quadrimucronatus cornutus** Ruedemann (**22**—18). N. Y. (Canajoharie).

G. whitfieldi (Hall) (**22**—19). Rhabdosome more slender than *G. ciliatus*, with sides diverging and again converging; thecae apparently with one nearly horizontal spine each. **M. Ord.:** Newf.; eastern Canada; N. Y. (Normanskill), Ark.; Bolivia; Great Britain (Glenkiln).

LASIOGRAPTUS Lapworth 1873

(**L. costatus*). Rhabdosome long and fairly narrow; thecae inclined at fairly low angles, furnished with spines; nemacaulus thin and usually shorter than rhabdosome. **L.** and **M. Ord.** (Que.; Me., Vt., N. Y., Ohio, Ark.; S. America; Europe; Australia).

L. (Hallograptus) mucronatus (Hall) (**22**—17). Synrhabdosome consisting of eight or more rhabdosomes; the latter long (over 35 mm), slender (1 to 2 mm), with rounded sicular extremity; thecae 8 to 10 in 10 mm, inclined at 20° to 30°, overlapping about a half; apertural margin horizontal or even receding, often concave; apertural excavation long, triangular, one-third the transverse width of the rhabdosome and one-half the length of the thecae. **M. Ord.:** Newf.; N. Y. (Normanskill), Ark. (Womble), Okla. (Stringtown); Great Britain (Glenkiln).

RETIOLITES Barrande 1850

(**Graptolithus geinitzianus* [Bulman (1938, D81) lists *Gladiolites* (*Retiolites*) *geinitzianus* Barrande as the genotype]). Rhabdosome with periderm attenuated and supported on a meshwork of fibers; thecae in two rows, opening outward; two virgulae attached to opposite sides, in median plane. **Ord., Sil.** (N. S.; N. Y., Ark.; Ireland and Scotland).

R. geinitzianus venosus (Hall) (**22**—15, 16). Thecae slightly oblique; apertural margin concave; periderm very tenuous. **M. Sil.:** N. S.; N. Y. (Clinton).

MONOGRAPTUS Geinitz 1852 emend auctt

(**Lomatoceras priodon* Bronn). Rhabdosome with only a single row of thecae, which in some American forms are drawn into bent points, at the apices of which are the apertures; rhabdosomes straight, curved, or sometimes spirally coiled. **Sil.** (Greenland; Arctic America; N. S.; Me., N. Y., Pa., Ind., Ark., Idaho; Great Britain; North Africa; Asia; Australia).

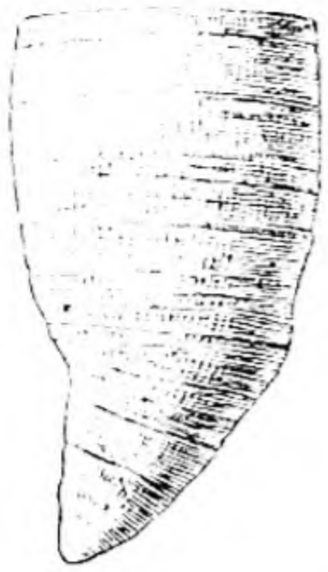
M. clintonensis (Hall) (**22**—20, 21). Stipe straight with well-marked virgula, ends of thecae bent over so that apertures in life opened upward. **M. Sil.:** N. S.; N. Y. (Clinton), Pa.

M. nilssoni (Barrande) (**22**—24). Rhabdosome slender, with length of several centimeters and width of 1 mm; with gentle double curve proximally and

PLATE 23

[Figures are x1 and after Bassler [JP 11] unless otherwise indicated.]

1, 2. Conchopeltis alternata [JP 11; photographs furnished by J. B. Knight]. Inclined lateral view of a paratype and top view of holotype. **3. Serpulites angustifolius** [N Y St G, An Rp 15]. **4–8. Porpites** spp. **4, 5. P. rotuloides** [Pal N Y 6]. Top and basal views. **6–8. P. michiganensis.** Basal and top views (x1.5), and portion of periphery (x4.5) showing strong crenulations. **9.** Kunth's diagram of a tetrameral coral [NAIF]. Ca, cardinal septum; Co, counter septum; A, alar septa. **10. Duncanella borealis** (x2) [Ind G S 11]. **11–14. Rhabdocyclus parvulus.** 11: Enlarged top view (x4). 12–14: Basal, top, and side views (all x1.5). **15–18. Microcyclus discus** (x1.5). Basal, side, and two top views of well preserved specimens. **19–23. Microcyclus thedfordensis** (x2). Basal, top, side, and top views of several specimens. **24–30. Hadrophyllum** spp. **24, 25. H. orbignyi.** Top and side views (x1.5). **26–28. H. ovale.** Top, side, and basal views (x1.5). **29, 30. H. aplanatum** [Bassler's figure after Cummins, Tex G S, An Rp 2]. Side and top views. **31–33. Dipterophyllum glans.** Top and side views (x1.5) and enlarged top view (x4). **34–37. Baryphyllum verneuilianum.** Basal, side, and top views (x1.5).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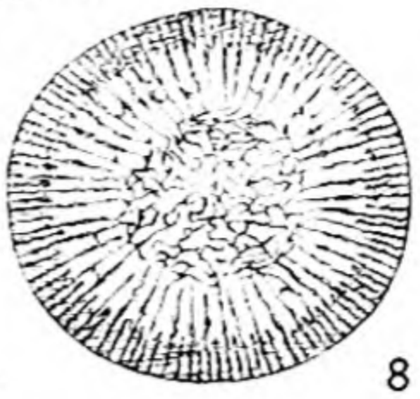
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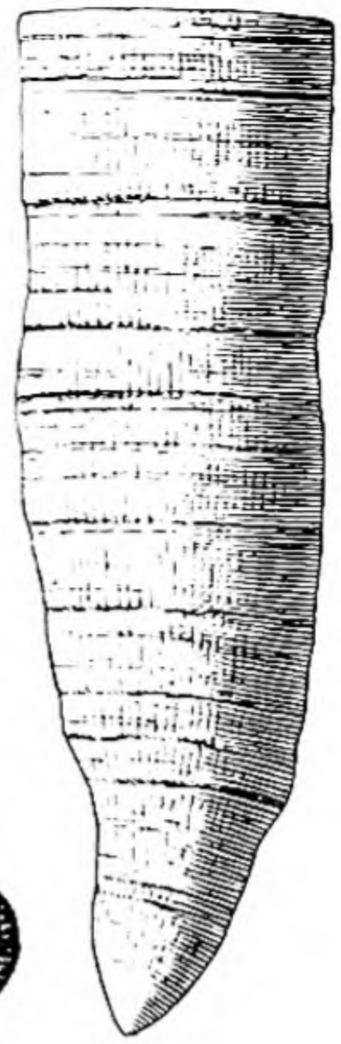
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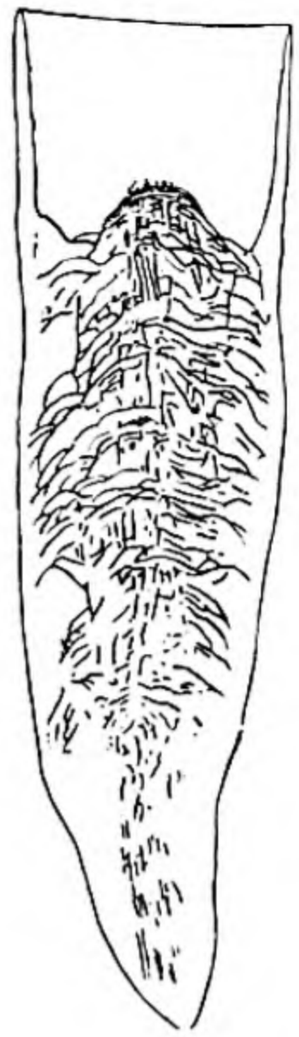
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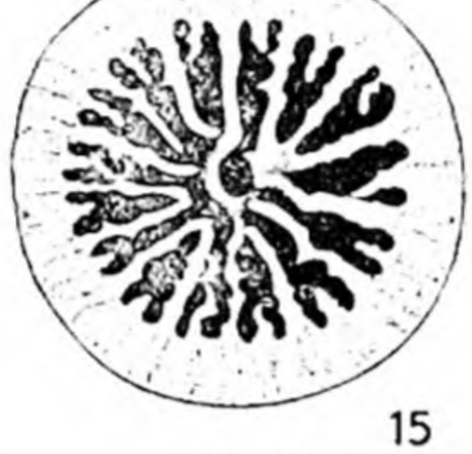
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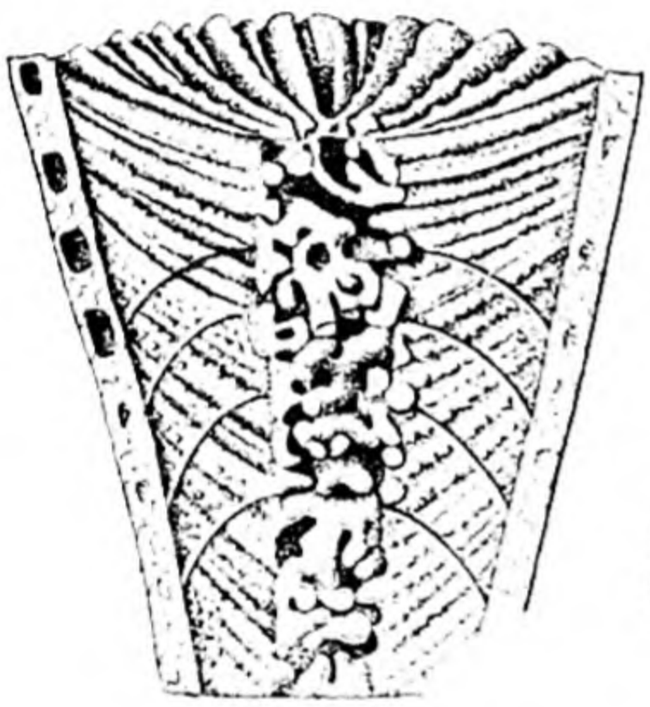
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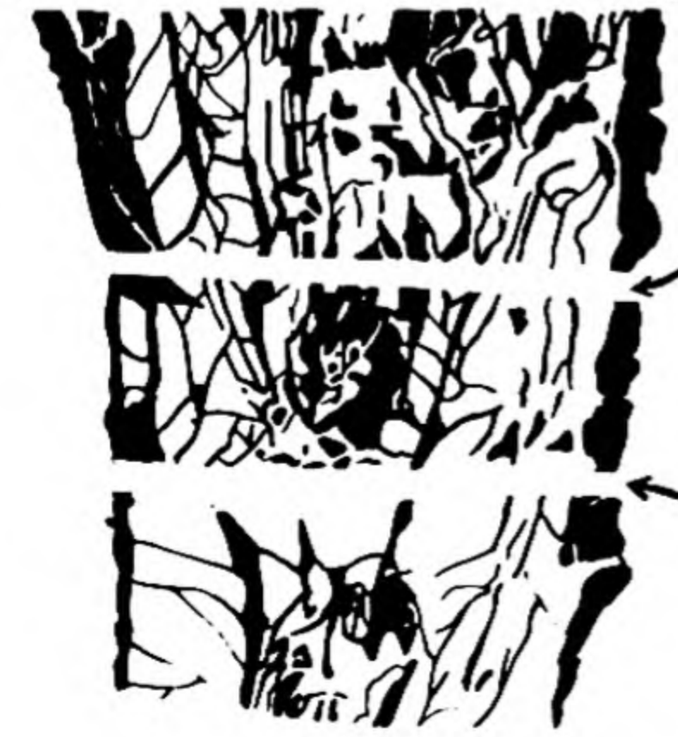
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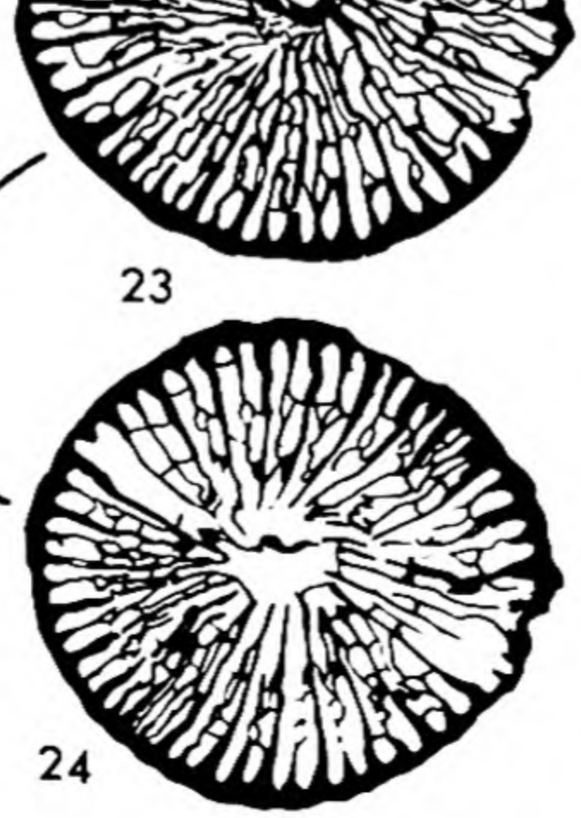
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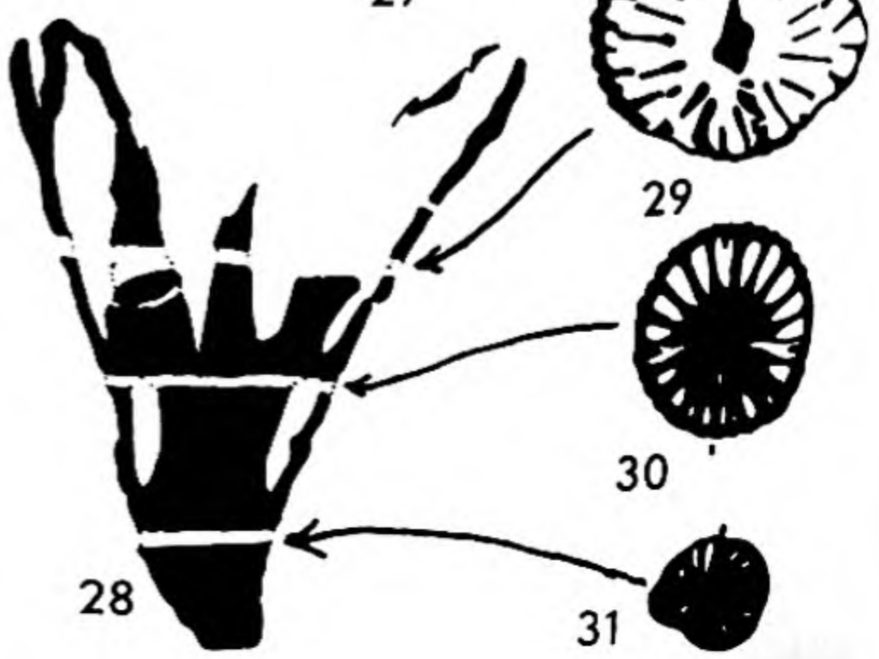
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usually straight distally; thecae 8 to 9 in 10 mm, simple, with slight sigmoid curve, 2 mm long, overlapping about a third their length; apertural margin straight, inclined about 20°; proximal end without sicula, generally narrow, 2 mm wide. **M. Sil.:** Me., Okla. (Henryhouse); Europe; Great Britain; Australia.

M. bohemicus (Barrande) (**22**—23). Rhabdosome broadly curved, long and relatively large (5 cm long, 0.25 to 2.4 mm wide); thecae 8 to 11 in 10 mm, simple tubes 2 mm long, 2 to 3 times as long as wide, overlapping a third to a half their length, inclined about 30°. **M. Sil.:** Ind.? (Mississinewa), Okla. (Henryhouse); Europe; Great Britain; Australia.

CYRTOGRAPTUS Carruthers 1867

(**C. murchisoni*). Like *Monograptus*, but curved and with secondary branches on one side. **M. Sil.** (Mo., Okla.; Europe).

C. ulrichi Ruedemann (**22**—25). Branches narrow and curved at base, widening and straightening outward; thecae scarcely projecting. **Niagaran:** Mo.

CLASS SCYPHOZOA

CONULARIDA[1]

For many years the Conularida have constituted a large, "catch-all" group of Paleozoic shells which show considerable variation in form, composition and structure. These shells have usually been assigned to the following five families: STYLIOLINIDAE, HYOLITHIDAE, TENTACULITIDAE, TORELLELLIDAE, and CONULARIDAE. All but the last are considered under Mollusca.

The conularids, as typified by *Conularia*, have been assigned to various biological groups in the past, but the general practice in the last quarter century has been to consider them mollusks. Recently, however, Kiderlen (1937) has assembled convincing observations to support his conclusion that *Conularia* and closely related genera are ancient **Scyphozoa.** He includes in his "Conularien" the following genera; *Serpulites*, first appearing in the Lower Cambrian; *Conulariella*, first known from the Middle Cambrian; and *Conularia*, unknown before the Upper Cambrian. Knight (1937) supports Kiderlen's conclusion and adds the Ordovician *Conchopeltis* to the Conularida. It is also probable that *Metaconularia* Foerste should be assigned to this group (see Boucek 1939, and Kieslinger 1939). *Calcolus* Hall and *Hyolithellus* Billings may belong here, but in this work they are included in the Mollusca under "Incertae sedis."

CONULARIA Miller 1818

(**C. quadrisulcata* Sowerby). Shell elongated pyramidal, with transverse section quadrangular; each lateral face marked by a median longitudinal groove; surface transversely striated or ribbed; posterior (apical) portion of shell divided off by septa; aperture constricted by four lobes incurved from the margin. **Ord.–Jura.** (widespread in eastern Canada and throughout U. S. A.).

C. trentonensis Hall (**22**—29, 30). Sides diverge from apex at about 25°; each side marked by transverse costae (2 to 4 in 1 mm) which are bent adaperturally, forming an angle of about 180° at the median line. **M. Ord.** (Trenton): Que.; N. Y. to Va., Ia.

C. niagarensis Hall (**22**—27, 28). **Sil.:** N. Y. (Rochester), Md., Ohio (Brassfield), Ind.

C. huntiana Hall (**22**—33, 34). **L. Dev.** (Helderbergian): N. Y., Tenn., Miss.

C. undulata Conrad (**22**—35, 36). **M. Dev.** (Hamilton): N. Y., Md.

C. missouriensis Swallow (**22**—32). Very large, elongated, four-sided, pyramidal with two opposite sides wider than other two; cross-section triangular; angles at four corners deeply furrowed longitud-

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[1] **Boucek, B.,** Conularida, in **O. H. Schindewolf's** Handbuch der Paläozoologie, Bd 2A: A113–A131, 1939 [Berlin]. **Calvin, S.,** *Conularia missouriensis* Swallow: *Am G* 5: 207–208, 1890. **Dyer, W. S.,** On *Conularia rugosa* from the Lockport limestone at Hamilton, Ontario: *R Soc Can*, Tr 15: 65–68, 1921. **Kiderlen, H.,** Die Conularien, Ueber Bau und Leben der ersten Scyphozoa: *N Jahrb f Min*, etc., B Bd 77, Abt B: 113–169, il, 1937. **Kieslinger, A.,** Medusae fossiles: *Fos Cat*, pars 26: 1–20, 1924; Scyphozoa, in **O. H. Schindewolf's** Handbuch der Paläozoologie, Bd 2A: A69–A109, il, 1939 [Berlin]. **Knight, J. B.,** *Conchopeltis* Walcott, an Ordovician genus of the Conulariida: *JP* 11: 186–188, il, 1937. **Kühn, O.,** Hydrozoa: *Fos Cat*, pars 36: 1–116, 1928; Hydrozoa, in **O. H. Schindewolf's** Handbuch der Paläozoologie, Bd 2A: A1–A68, il, 1939 [Berlin]. **McKee, E. D.,** A *Conularia* from the Permian of Arizona: *JP* 9: 427–429, 1935. **Roy, S.,** A new Niagaran *Conularia*: *Field Mus N H*, gs Pub 6: 147–154, il, 1935. **Ruedemann, R.,** The discovery of a sessile *Conularia*: *N Y St G*, An Rp 15: 701–720, il, 1898. **Sinclair, W.,** The genotype of *Conularia*: *Can Field-Nat* 54: 72–74, 1940; A discussion of the genus *Metaconularia* with descriptions of new species: *R Soc Can*, Tr 34: 101–121, il, 1940; The Chazy Conularida and their congeners: *Carnegie Mus*, An 29: 219–240, il, 1942. **Walcott, C. D.,** Fossil medusae: *USGS*, M 30: 1–201, il, 1898.

PLATE 24

[Figures are x1 unless otherwise indicated.]

1–10. Streptelasma spp. **1–3. S. corniculum** [CGS, Contr Can Pal 4]. Exterior; longitudinal and cross sections. **4–7. S. petoskeyense** [JP 13]. 4: Section of neanic septa (x5.3). 5–6: Cross and longitudinal sections (x1.3); and cross section of neanic portion (x1.3). **8–10. S. rusticum** [CGS, Contr Can Pal 4]. Cross section, exterior, and longitudinal section. **11–16. Enterolasma** spp. **11–13. E. caliculum.** Cardinal and calicular views [N Y St Mus, B 45]; longitudinal section [CGS, Contr Can Pal 4]. **14–16. E. strictum** [N Y St Mus, B 39]. Longitudinal (x2.5) and cross (x5) sections showing septal structure. **17–20. Stereolasma rectum.** Alar and cardinal views [NAIF]; enlarged cross and longitudinal sections (x2) [N Y St Mus, B 39]. **21–24. Duplophyllum septarugosum** [Kan G S, B 38; drawings furnished by R. C. Moore]. Longitudinal and cross sections (x3). **25–27. Hapsiphyllum calcariforme.** Lateral and top views [Ind G S 12]; enlarged calicular view (x2) [N Y St Mus, B 39]. **28–31. Malonophyllum kansasense.** Longitudinal and cross sections (x3) [Kan G S, B 38; drawings furnished by R. C. Moore].

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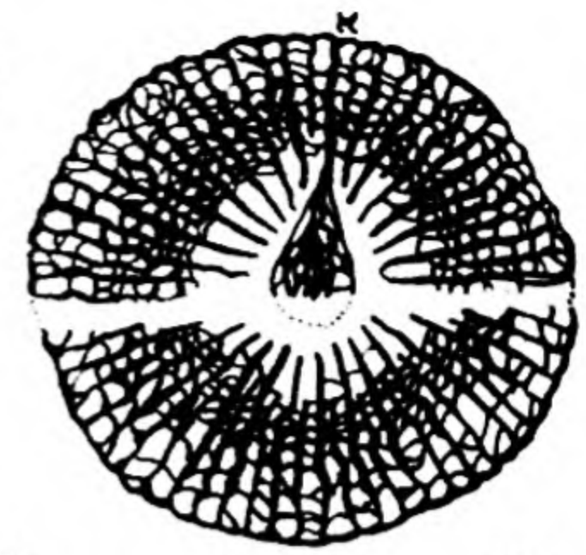
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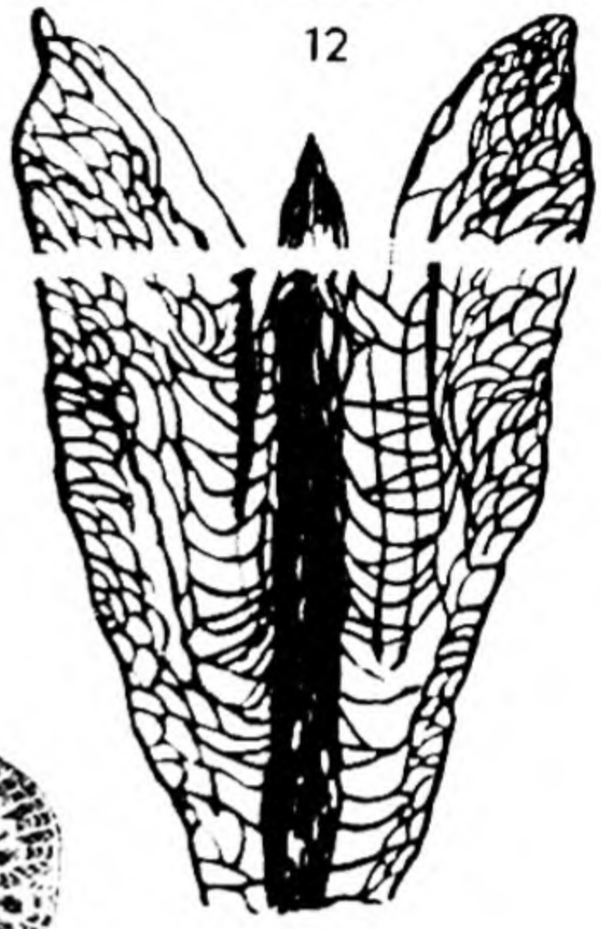
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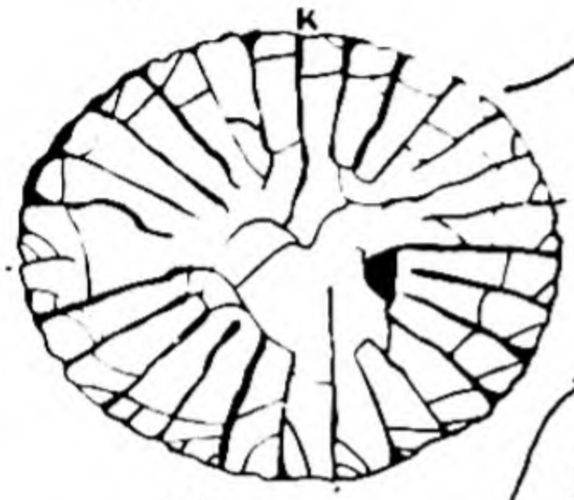
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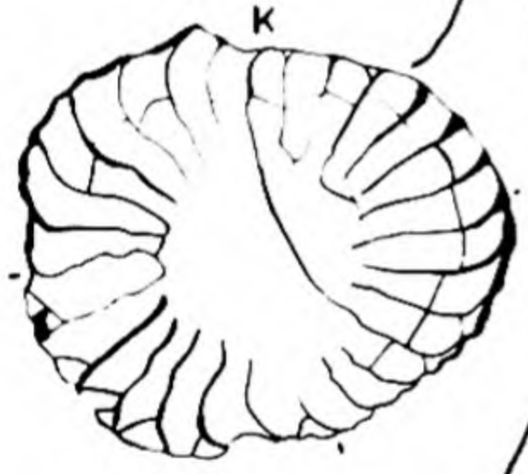
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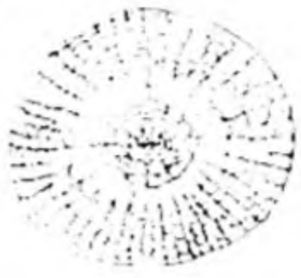
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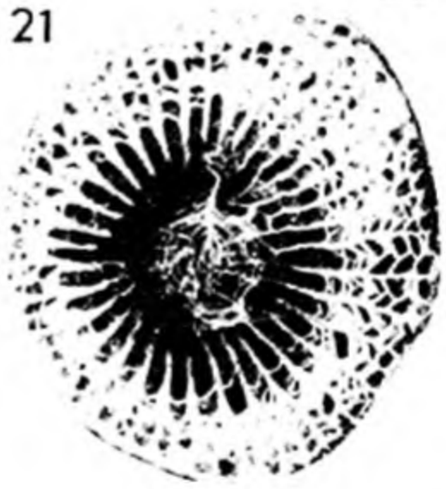
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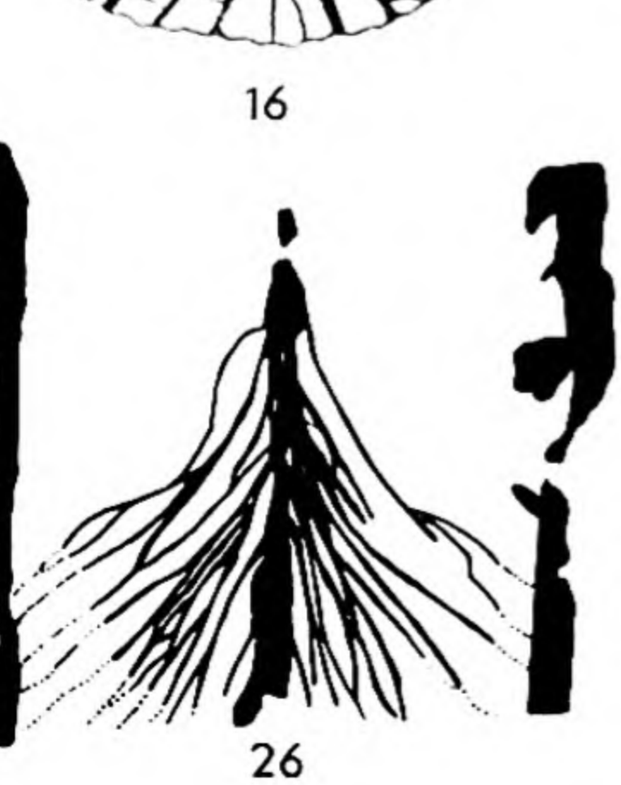
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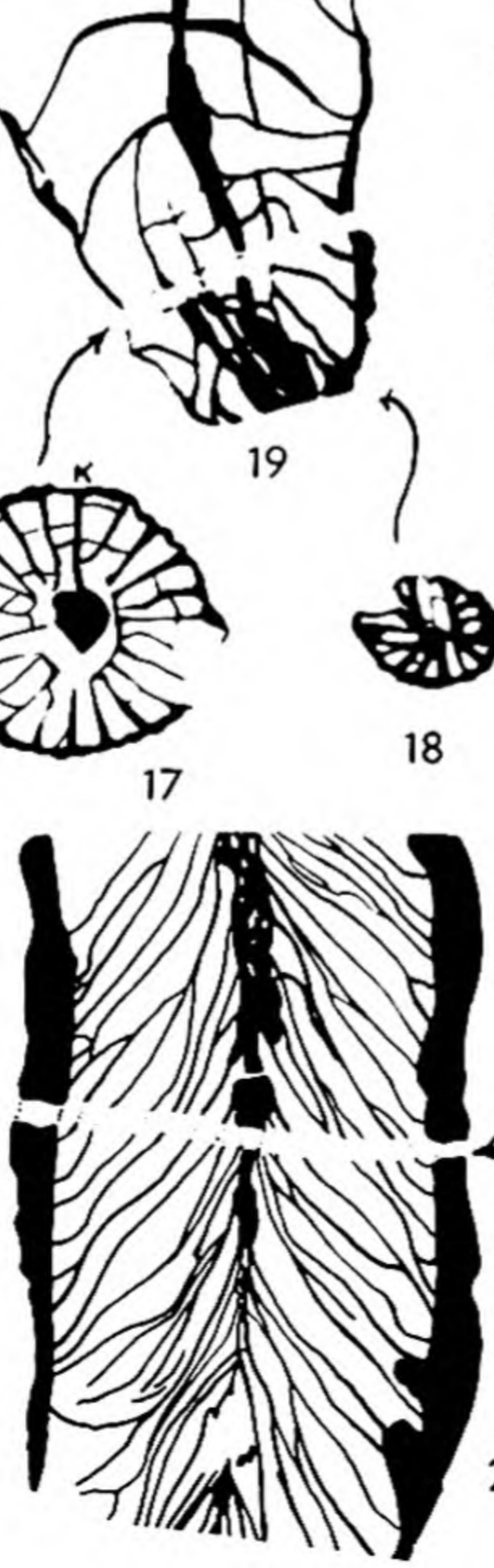
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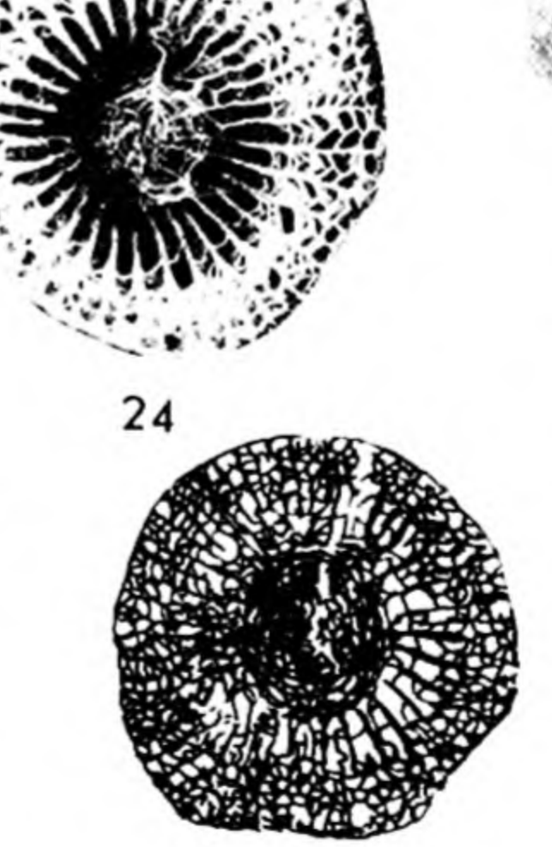
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inally; sides without distinct median groove. **Miss.** (Warsaw and St. Louis): Ind., Ill., Mo., Nev.

C. crustula White (**22**—26). Small, with four sides equal; four angles distinctly furrowed, with slender median furrow also. **Penn.:** Mo., Ark., N. Mex.

METACONULARIA Foerste 1928

(**Conularia aspersa* Lindström). Shell like typical *Conularia* in form, but very thin and with surface bearing very minute granules or papillae, usually too small to be distinguishable readily with unaided eye, and arranged in numerous transverse and vertical rows; each of the four faces of the shell is supplied on its interior with two vertical septa which are close to the median line of each face; these septa are thin and project inward only 0.05 mm or less; no thickening at margin of shell. **M. Ord.–U. Sil.** (Ont.; N. Y., Wis., Ill., Mo.; Gotland; Bohemia; England).

M. ulrichi Foerste (**22**—31). **M. Ord.:** Wis (Black River).

CONCHOPELTIS Walcott 1875

(**C. alternata*). Shell apparently thin, fragile and almost flexible; form a low symmetrical cone with four lobes arranged in quadrilateral radial symmetry; eight structures interpreted as muscle scars are arranged symmetrically in four pairs. **M. Ord.** (N. Y.).

***C. alternata** Walcott (**23**—1, 2). **Trenton:** N. Y.

SERPULITES Murchison 1839

(*S. longissimus*). Shell flattened with elliptical cross-section and edges thickened; surface with fine transverse or sometimes longitudinal striae. **L. Camb.–Perm.** (N. America: Sweden; England; India).

S. angustifolius (Hall) (**23**—3). **M. Ord.:** N. Y. (Canajoharie).

CLASS ANTHOZOA[1,2]

This class contains a large group of marine animals ranging from low tide to depths as great as 9,000 feet,

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[1] We take pleasure in acknowledging the valuable assistance of the following: Drs. G. M. Ehlers, Winifred Goldring, W. A. Kelley, and Grace Stewart, who aided in many ways in revision of the middle Paleozoic genera; Drs. R. C. Moore and R. M. Jeffords, who furnished descriptions and illustrations of a number of Pennsylvanian and Permian species; and Drs. J. W. Durham, L. W. Stephenson, T. W. Vaughan, and J. W. Wells, who helped in revision of the Mesozoic and Cenozoic Hexacoralla.

[2] **Bassler, R. S.,** The Paleozoic rugose family Paleocyclidae: *JP* 11: 189–201, il, 1937. **Coryell, H. N.,** and **Ohlsen, V.,** Fossil corals of Puerto Rico: *N Y Ac Sc, Surv Puerto Rico and Virgin Is.* 3 (2): 168–236, il, 1929. **Cox, I. H.,** Revision of *Calapoecia* Billings: *Can Nat Mus,* B 80, gs 53: 1–49, il, 1936. **Davis, W. J.,** Kentucky fossil corals, Pt 2: *Ky G S,* pl 1–139, 1885. **Diener, C.,** Cnidaria triadica: *Fos Cat,* pars 13: 1–46, 1921. **Felix, J.,** Anthozoa palaeocretacea: Idem, pars 5: 1–84, 1914; Anthozoa cenomanica: Idem, pars 6: 1–59, 1914; Anthozoa neocretacea: Idem, pars 7: 1–129, 1914; Anthozoa eocaenica et oligocaenica: Idem, pars 28: 1–296, 1925; Anthozoa miocaenica: Idem, pars 35: 1–194, 1927; Anthozoa pliocaenica et plistocaenica (cum indice ad omnes partes Anthozoarium tertiarium et quaternarium): Idem, pars 44: 1–180, 1929. **Fenton, C. L.** and **M. A.,** The "Tabulate" corals of Hall's "Illustrations of Devonian Fossils": *Carnegie Mus,* An 25: 17–58, pl 1–8, 1936; *Aulopora,* a form-genus of tabulate corals and bryozoans: *Am Mid Nat* 18: 109–114, il, 1937; *Heliophyllum* and "*Cystiphyllum,*" corals of Hall's "Illustrations of Devonian Corals". *Carnegie Mus,* An 27: 207–250, pl 17–24, 1938. **Fenton, M. A.,** Species of *Aulopora* from Traverse and Hamilton groups: *Am Mid Nat* 18: 115–128, pl 1–6, 1937. **Gane, H. S.,** Some Neocene corals of the United States: *USNM,* Pr 22: 179–198, 1900. **Grabau, A. W.,** Paleozoic corals of China, Pt 1, Tetraseptata: *Pal Sinica,* Ser B, v 2 (1, 2): 1–76, 1–175, il, 1922, 1928. **Grove, B. H.,** Studies in Paleozoic corals: *Am Mid Nat* 15: 97–137, il, 1934; A revision of some Mississippian zaphrentids: Idem 16: 337–378, il, 1935. **Hall, J.,** Illustrations of Devonian fossils: corals of the Upper Helderberg and Hamilton groups: *N Y G S,* Pal: pl 1–39, 1876; Fossil corals of the Niagara and Upper Helderberg groups: *Ind G S,* An Rp 12: 271–318, pl 1–28, 1883. **Hayasaka, I.,** North American species of *Lithostrotionella: Taihoku Imp Univ,* Mem 13: 47–73, il, 1936. **Heritsch, F.,** A new species of *Waagenophyllum* from Permian of Texas: *AJS* 31: 144–148, 1936; A new rugose coral from Lower Permian of Texas, with remarks on the stratigraphic significance of certain Permian coral genera: *AJS* 32: 134–144, 1936. **Hill, D.,** The Devonian rugose corals of Lilydale and Loyola, Victoria: *R Soc Victoria,* Pr 51: 219–256, il, 1939. **Jeffords, R. M.,** Lophophyllid corals from Lower Pennsylvanian rocks of Kansas and Oklahoma: *Kan G S,* B 41: 185–260, il, 1942. **Kelly, W. A.,** Lithostrotiontidae in the Rocky Mountains: *JP* 16: 351–361, il, 1942. **Lambe, L. M.,** Canadian Paleozoic corals: *CGS,* Contr Can Pal 4: 1–197, pl 1–18, 1899, 1901; *Ottawa Nat* 12: 217–226, 237–258, 1899. **Lang, W. D., Smith, S.,** and **Thomas, H. D.,** Index of Paleozoic coral genera: *Brit. Mus Rp,* p 1–231, 1940 [Reviewed by **J. B. Knight** in *JP* 15: 178–180, 1941]. **Lewis, H. P.,** Lower Carboniferous corals of Nova Scotia: *An Mag N H* 16: 118–142, 1935. **Milne Edwards, H.,** and **Haime, J.,** Monographie des Polypiers Fossiles des Terraines Paléozoique: *Arch du Mus Paris* V, 1851 (and numerous other important monographs). **Moore, R. C.,** and **Jeffords, R. M.,** New Permian corals from Kansas, Oklahoma, and Texas: *U Kan Pub, G S Kan B* 38; 65–120, pl 1–8, 1941. **Nicholson, H. A.,** Tabulate corals of the Palaeozoic Period, Blackwood & Sons, 1879 [also see Zittel, Textbook of Palaeontology]; Corals of the Silurian and Devonian: *Ohio G S* 2: 181–242, il, 1875. **Nomland, J. O.,** Corals from the Cretaceous of California and Oregon: *U Cal Dp G,* B 9: 59–76, il, 1917; New fossil corals from the Pacific coast: Idem 10: 185–190, 1917. **O'Connell, M.,** Revision of *Zaphrentis: N Y Ac Sc,* An 23: 177–192, 1914. **Okulitch, V.,**

PLATE 25

[Figures are x1 unless otherwise indicated; Figs. 8–19 and 26–30 were furnished by R. C. Moore and appear in Kan G S, B 38.]

1–11. Lophophyllidium spp. **1–3. L. proliferum** [McChesney: 1860–65]. **4, 5. L. proliferum** [Ind G S 13]. **6, 7. L. proliferum** [Kan G S 6]. **8–11. L. dunbari.** Cross and longitudinal sections of type specimen (x3). **12, 13. Heritschia girtyi.** Cross and longitudinal sections of type (x3). **14–19. Lophamplexus eliasi.** Cross and longitudinal sections of type (x3). **20–22. Axophyllum rude** [Kan G S 6]. Side and top views, and cross section enlarged (x2). **23–25. Dibunophyllum valeriae** [JP 9]. Cross and longitudinal sections (x2). **26–28. Leonardophyllum distinctum** (x3). Longitudinal section showing calyx, and longitudinal and cross sections of type. **29. Heritschia columbica** (x2.4). **30. Waagenophyllum texanum** (x3).

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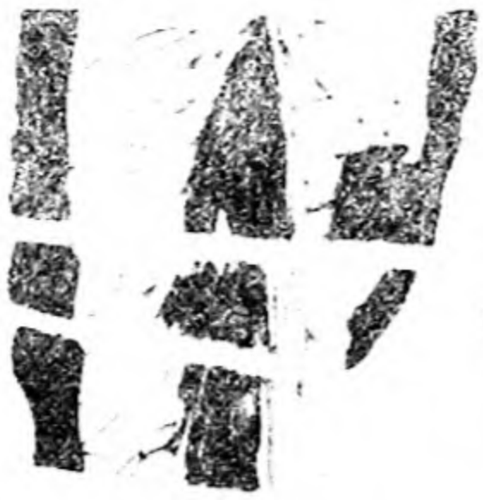

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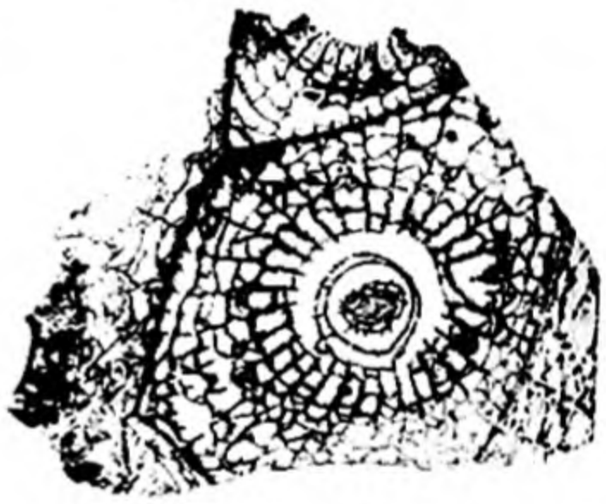

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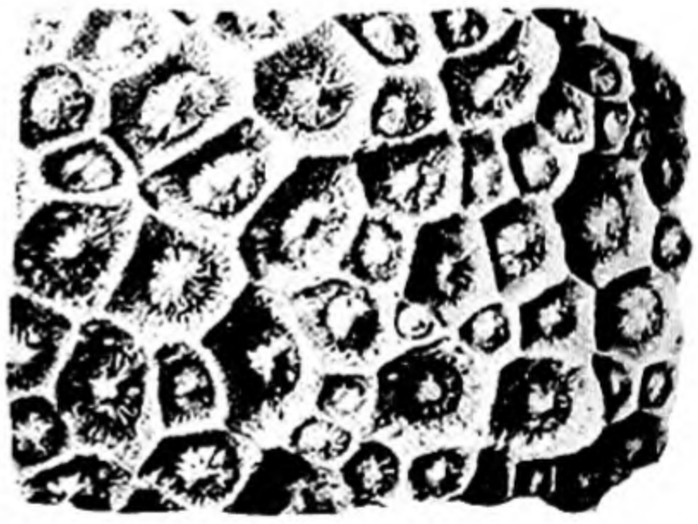

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but chiefly at home in tropical waters less than 300 feet deep.

The animal (*polyp*) consists of a barrel-shaped body with a circle of tentacles surrounding the mouth, which is situated at the free end; internally it is partly divided into compartments by radial partitions or *mesenteries*. The outer layer (*ectoderm*) of the entire width of the polyp opposite the mouth typically secretes a basal plate of calcium carbonate, upon which are later developed the radiating calcareous plates (*septa*) which are deposited in inward and upward folds between the mesenteries. Since the lower part of the outer polyp wall also secretes calcium carbonate, an outer wall, the *theca*, is commonly formed around this basal plate and is typically developed in the **Tetracoralla.** This theca, especially its continuation above the base, probably at times an added deposit of calcium carbonate due to sagging of the polyp, is usually termed *epitheca*.

Within the soft body wall calcareous secretion may also go on, giving rise to various hard parts. With the upward growth of the theca, its lower portion, no longer occupied by the polyp, is partitioned off. The calcareous partitions are designated *dissepiments* if they lie between septa and *tabulae* if they extend partly or entirely across the theca. Secondary deposits, known as *stereoplasm*, may be made on these primary structures.

The animal may be simple (solitary) or it may give rise by budding or division to a colony in which individuals may be distinct or confluent; thus the *corallum* or hard structure secreted by the organisms may be simple or compound. The skeleton (really an exoskeleton) secreted by an individual is termed a *corallite*. The upper part of the corallite, which is usually a prominent depression, is the *calyx* and is the place where the animal lives. In compound forms of closely crowded corallites, the epitheca of the exposed portion of the outer corallites commonly unites to form a continuous *peritheca*, which envelopes the base and sometimes the sides of the entire colony.

Typically, each corallite has a circumferential wall and radiating lamellae or septa, though either one or the other of these may be much reduced or even lacking. The wall or theca may be an independent structure, growing upward like the septa from the bottom of the corallum, especially in the **Tetracoralla;** or it may be formed of the thickened and fused outer ends of the septa, in which case it is designated a *pseudotheca* (common in **Hexacoralla**). The outer ends of the septa are frequently continued beyond the thecal wall as *costae*. The septa may be rudimentary and the dissepiments and tabulae reduced to superimposed curved plates, as in *Cystiphyllum*, so that the structure is cystose. Septa may be smooth or granulose, or they may bear horizontal, conical or cylindrical rods (*synapticula*).

Tetradidae: a revision of *Tetradium: R Soc Can* 3 (4) Tr 29: 49–74, 1935; Some Chazyan corals: Idem 30: 59–73, 1936; *Heliolites, Tetradium,* and *Chaetetes: AJS* 32: 361–379, 1936; Some Black River corals: *R Soc Can* 3 (4) Tr 32: 87–111, 1938; Evolutionary trends of some Ordovician corals: Idem 33: 67–80, 1939. **Okulitch, V.,** and **Albritton, C. C.,** *Malonophyllum,* a new tetracoral from the Permian of Texas: *JP* 11: 24–25, il, 1937. **Palmer, R. H.,** Fossil and recent corals and coral reefs of western Mexico: *Am Phil Soc,* Pr 67: 21–31, 1928. **Plummer, F. B., Moore, R. C.,** and **Jeffords, R. M.,** L. Penn. corals from Texas and adjacent states: *U Tex B* (in press). **Quayle, E. H.,** *Caryophyllia* from California [Abst]: *GSA,* B 42: 369, 1931; *Turbinolia* from Eocene of California: *San Diego Soc N H* 7: 91–109, il, 1932. **Rominger, C. L.,** Fossil corals: *Mich G S* 3 (2): 1–161, pl 1–55, 1876. **Sanford, W. G.,** A review of the families of tetracorals: *AJS* 237: 295–323, 1939. **Simpson, G. B.,** New genera of Paleozoic rugose corals: *N Y St Mus,* B 39: 199–222, il, 1900. **Sloss, L. L.,** Devonian rugose corals from Traverse beds of Michigan: *JP* 13: 52–73, il, 1939. **Smith, S.,** *Xylodes rugosus,* sp. nov.: *AJS* 26: 512–522, il, 1933; Anthracolitic corals from British Columbia, etc. *JP* 9: 30–42, il, 1935. **Stainbrook, M. A.,** *Prismatophyllum* in Cedar Valley beds of Iowa: *JP* 14: 270–284, il, 1940. **Stephenson, L. W.,** North American Upper Cretaceous *Micrabacia: USGS,* PP 98: 115–131, il, 1916. **Stewart, G.,** Middle Devonian corals of Ohio: *GSA,* SP 8: 1–120, pl 1–20, 1938. **Stumm, E. C.,** Corals of the Nevada limestone: *JP* 11: 423–443, il, 1937; 12: 478–485, il, 1938; 14: 58–67, il, 1940. **Swartz, C. K.,** Coelenterata. *Md G S,* L. Dev: 195–227, il, 1913. **Vaughan, T. W.,** Some Cretaceous and Eocene corals from Jamaica: *MCZ (Harvard),* B 34: 227–250, il, 1899; Eocene and L. Oligocene coral faunas of the United States: *USGS,* Mon 39: 1–263, pl 1–24, 1900; A critical review of the literature of the simple genera of *Madreporaria Fungida,* with a tentative classification: *USNM,* Pr 28: 371–424, 1905; Fossil corals of Canal Zone and related areas of Central America, and West Indies: *USNM,* B 103: 189–524, pl 74–152, 1919. **Vaughan, T. W.,** and **Hoffmeister, J. E.,** Fossil corals from Dominican Republic: *MCZ (Harvard),* B 67: 315–326, 1925. **Vaughan, T. W.,** and **Wells, J. W.,** Check list of generic names applied to the *Madreporaria Hexacoralla,* 1–36 [La Jolla, Cal.], 1936; Revision of the suborders, families and genera of the madreporarian hexacorals [Abst]: *GSA,* Pr 1936: 359, 1937. **Wells, J. W.,** Corals of the Trinity of central Texas: *JP* 6: 225–256, 1932; Cretaceous corals of Atlantic and Gulf Coastal Plains and Western Interior: *B Am Pal* 18: 1–204, il, 1933; Eocene corals: Idem 20: 1–20, il, 1934; Some fossil corals from the West Indies: *USNM,* Pr 83: 71–110, il, 1934; The nomenclature and type species of some genera of recent and fossil corals: *AJS* 31: 97–134, 1936; *Heliophyllum halli* E and H: *Pal Am* 2 (6): 1–22, 1937; New genera of Mesozoic and Cenozoic corals: *JP* 11: 73–77, 1937. **Werner, C.,** Synonymy of mid-Devonian corals of Falls of the Ohio: *Wash Univ (St Louis) Stud ns Sc and Tech* 7: 113–122, 1932; 9: 53–64, 1936.

PLATE 26

[Figures are x1 and after Hayasaka [Taihoku Imp Univ, Mem 13] unless otherwise indicated.]

1–3. Leonardophyllum acus [Kan G S, B 38; drawings furnished by R. C. Moore]. Cross section and longitudinal sections of type (x3). **4–8. Lithostrotion** spp. **4, 5. L. whitneyi** (x3) [photograph furnished by W. A. Kelly]. **6–8. L. proliferum** [Ia G S 1]. Longitudinal and transverse sections enlarged (x3), and part of a corallum. **9–17. Lithostrotionella** spp. **9–12. L. castelnaui** [USGS, PP 36]. Longitudinal and cross sections of a corallite (x2); side and top views of a corallum (x0.5). **13, 14. L. americana.** Cross section (x2) and top view. **15–17. L. hemisphaerica.** Cross and longitudinal sections enlarged; top view of a corallum [Mo G S 4].

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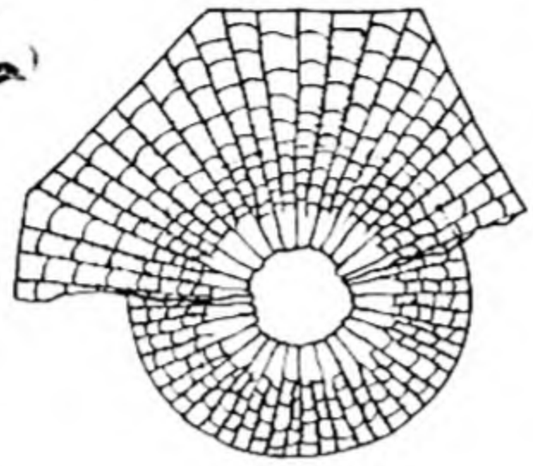

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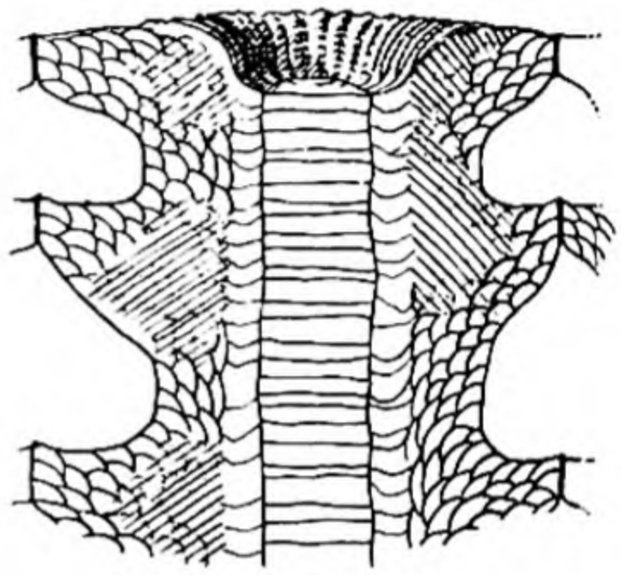

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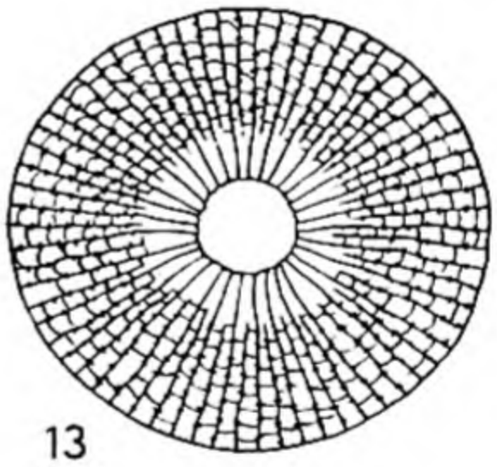

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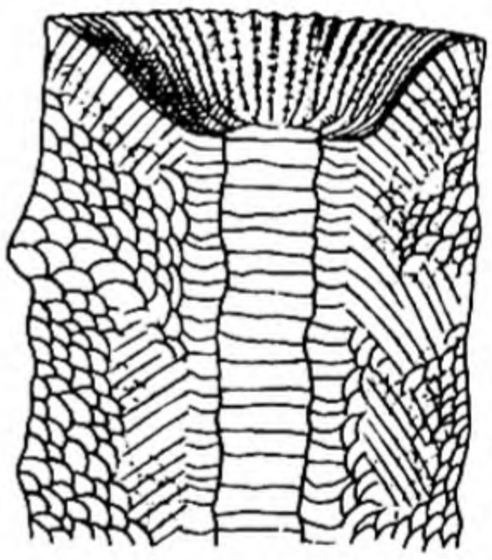

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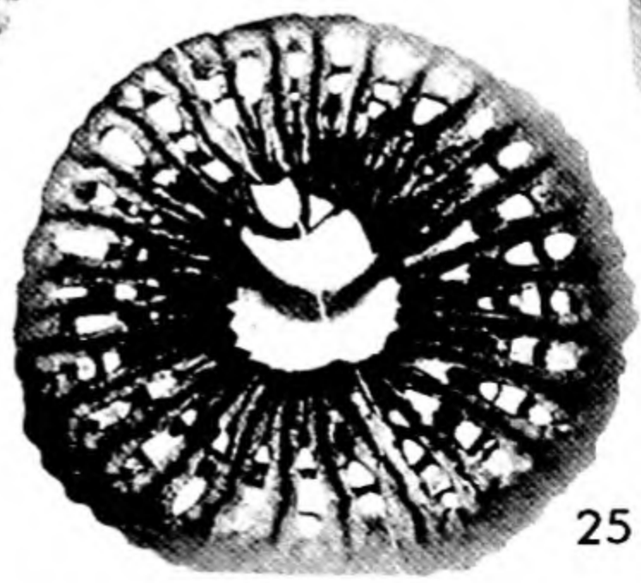

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which frequently unite between adjacent septa, or radial rods (*trabeculae*). Often septa may also be reinforced by vertical ridges, which in transverse section or in the calyx appear as short spines (*carinae*) extending outward from the septum (*Heliophyllum*). The upper edges of the septa in the calyx may be smooth or spinous. A structure known as the *columella* or *pseudocolumella* is commonly present in the axial region of the corallite. A true columella, which is typical only in the **Hexacoralla,** extends from apex to calyx, as in *Turbinolia*. It may be simple or complex, a solid rod or a spongy structure. In the **Tetracoralla** it is a secondary structure that is absent in the young. As used in the following discussion, columella refers to the axial structure formed by thickening along the line where the septa meet — of all septa in *Lithostrotionella* and of a thickening of the inner and counter septum in *Lophophyllidium*. Similar projections, formed in other ways, in the center of the calyx are *pseudocolumellae*. These may be formed by twisting of the inner ends of the septa (*Streptelasma*), by a sharp upward arching of the tabulae in the center (*Acrophyllum*), etc.

The tetracorals have the septa arranged in four groups or quadrants, which are separated by the four primary septa — *cardinal*, *counter*, and two *alar* (**23**—9). With growth the quadrants rapidly become filled with secondary septa which commonly equal the primary ones in length. This tetrameral arrangement is also frequently marked upon the outer surface of the theca. The cardinal septum may be so reduced that its position is marked by a groove or *fossula*; similar grooves in other positions are designated *pseudofossulae*. Most Mesozoic and later corals have the septa arranged in multiples of six. The septa are frequently very numerous and most of the cycles of septa reach near or to the center of the corallite or corallum. As the polyp grows in circumference and adds new mesenteries and new tentacles, the calcareous base also increases in size and new septa, some of which may reach only part way to the center, develop between the older ones.

The corallites in compound coralla may be crowded, in which case they are generally prismatic in form; or they may be far apart, remaining either completely dissociated at the upper surfaces (*Syringopora*) or becoming connected by a dense or coarse calcareous *coenenchyma*. This connective material, either dense or vesicular in structure, is secreted by the common colonial tissue (*coenosarc*) which extends like a carpet between the polyps. The corallites occasionally are connected by nothing more than strongly developed costae. In a few cases they become confluent by incomplete division and then the corallum surface consists of sinuous grooves in which the septa point toward the center or axial line. If the septa are lacking, tabulae generally are well developed, as in *Favosites*, and these latter may be funnel-shaped (*Syringopora*). The walls of tabulated corallites frequently are pierced by numerous *mural pores* regularly or irregularly arranged. A series of small shelves or *squamae* generally occur on the inside of the wall near these pores.

Many technical terms not discussed here will be found in the references listed at the beginning of this section, particularly in works by Grabau, Grove, Sanford, and Vaughan.

Subclass Tetracoralla

(= **Zoantharia Rugosa** Milne Edwards; **Pterocorallia** Frech; **Tetraseptata** Grabau)

Simple or compound corals with imperforate septa arranged tetramerally with bilateral or radial symmetry; without coenenchyma, but usually with strongly developed endothecal material in the form of tabulae and dissepiments, and with well-marked and frequently wrinkled epithecal wall; coralla never dimorphic. **Ord.–Perm.**

DUNCANELLA Nicholson 1874

(**D. borealis*). Corallum simple, slender, with radial septa; tabulae and dissepiments lacking. **Sil.**

D. borealis Nicholson (**23**—10). Small, scarcely over 12 mm long; costae well developed. **Niagaran:** Ind., Tenn.

PORPITES Schlotheim 1820

(= PALEOCYCLUS Edwards and Haime 1849)

(**P. globulatus* Schlotheim). Corallum small, discoidal, with flat epithecated base bearing a small centrally placed cone of attachment perpendicular to disk; calyx with major and minor spinose septa radiately arranged, the major bearing moniliform transverse dilatations and reaching to center; no fossulae, tabulae, or dissepiments. **Sil.–Cret.**

P. rotuloides (Hall) (**23**—4, 5). About 20 major crenulated septa and 20 shorter secondary ones which extend only about a fourth the distance to center. **Niagaran** (Clinton): N. Y., Md., Pa.

P. michiganensis (Bassler) (**23**—6–8). Differs from preceding in its more conical base, thicker

PLATE 27

[Figures are x1 unless otherwise indicated.]

1–14. Eridophyllum spp. **1–5. E. seriale.** A group of corallites (x1) and two enlarged (x2) sections [AJS (5): 26]; cross and longitudinal sections (x2) [GSA, SP 8]. **6–10. E. colligatum.** Diagrammatic sections enlarged (x2) [CGS, Contr Can Pal 4]; two views of portion of corallum [GSA, SP 8]. **11–14. E. archiaci.** Two fragmental specimens [NAIF]; diagrammatic sections (x2) [CGS, Contr Can Pal 4]. **15–17. Zaphrentis phrygia** [GSA, SP 8]. Three views of a specimen. **18–26. Neozaphrentis** spp. **18–20. N. tenella.** Cross section enlarged (x3) [Am Mid Nat 16]; two views of a specimen [Ind G S 17]. **21, 22. N. racinensis** [Geol Wis 4]. A calyx filling. **23–26. N. wannensis** [JP 9] Two views of a specimen, and two enlarged (x4) sections.

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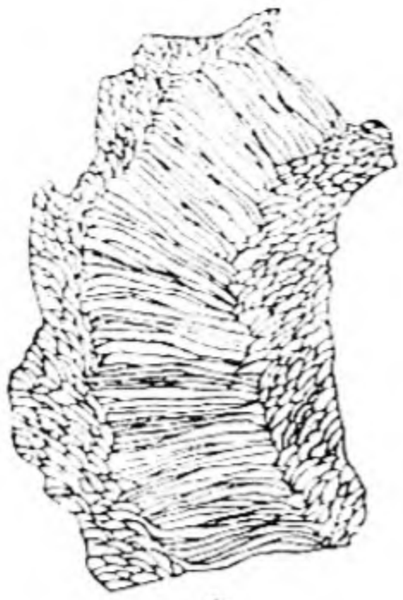

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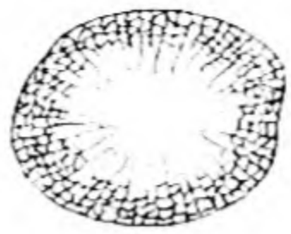

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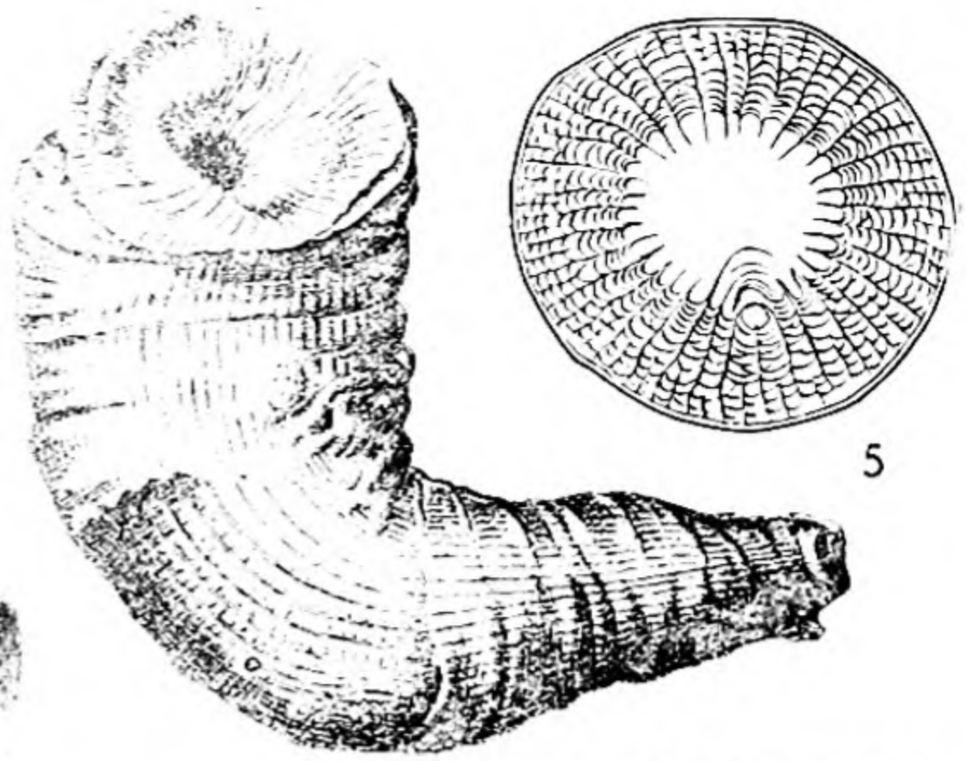

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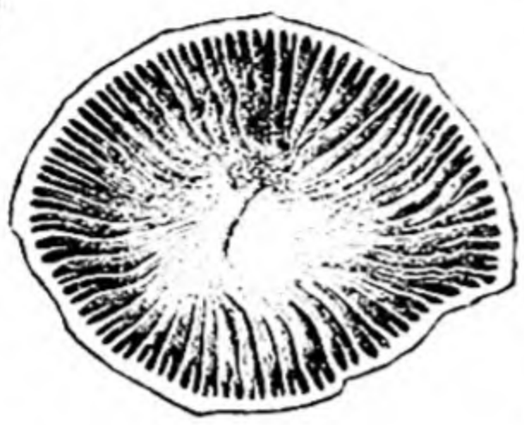

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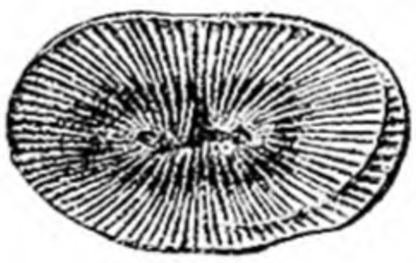

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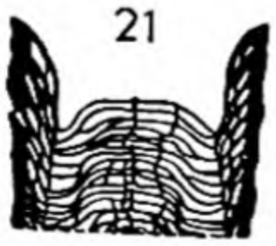

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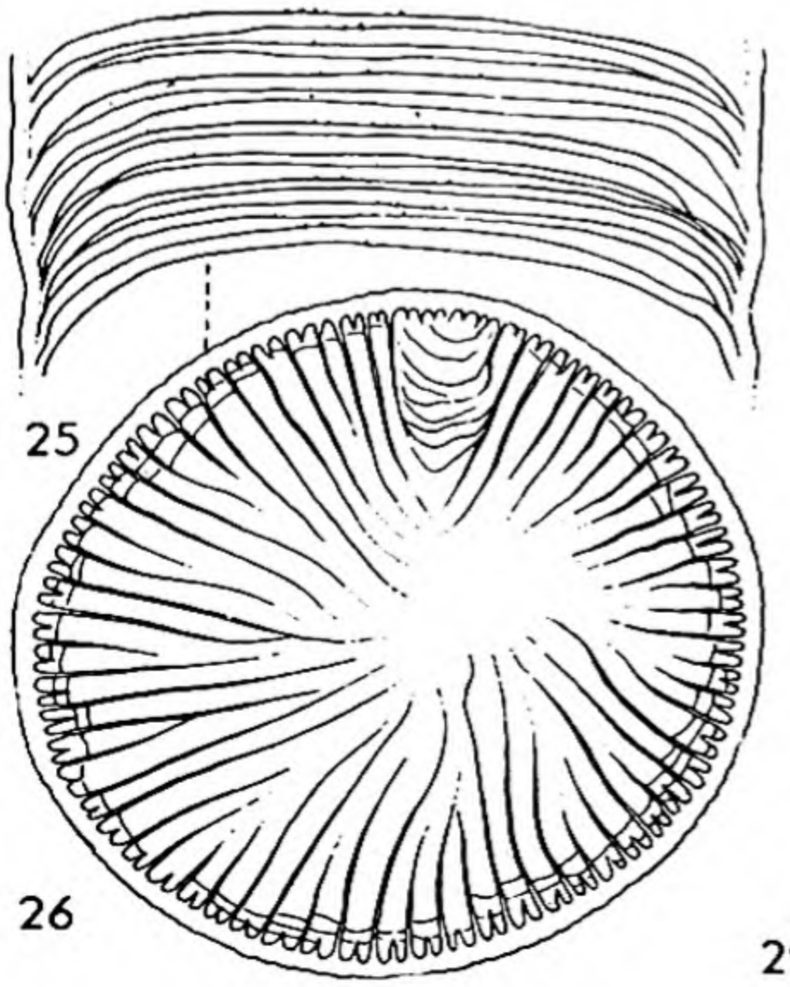

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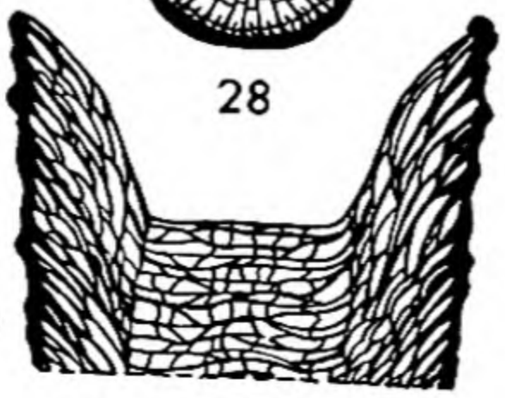

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epitheca, more prominent and sharply spinose but thinner major septa (about 22), and its short but equally spinose minor septa which reach about a third of the way to the center. **Niagaran:** Mich. (Manistique).

RHABDOCYCLUS Lang and Smith 1939

(= ACANTHOCYCLUS Dybowski 1873)

(**Paleocyclus fletcheri* Edwards and Haime). Like *Porpites* except that basal cone of attachment (peduncle) is eccentric and directed obliquely to corallum; septa strongly crenulated, the major ones meeting in calyx outside center, and the minor much shorter. **Sil.** (U. S. A.; England; Estonia).

R. parvulus Bassler (**23**—11–14). **Niagaran: Ia.**

MICROCYCLUS Meek and Worthen 1868

(**M. discus*). Coralla free, thin, discoidal, with a small central irregular basal scar of attachment and a shallow calyx with smooth septa arranged in four groups separated by fossulae, of which the cardinal one is best developed: cardinal fossula with septum. **Dev., Miss.**

***M. discus** M and W (**23**—15–18). **M. Dev.:** Ill.

M. thedfordensis Bassler (**23**—19–23). This species, usually misidentified as the preceding, is distinguished from that form by the smaller smooth central area, the major septa extending nearer the center, the minor septa usually more distinct and shorter and seldom united with the major, and the cardinal fossula deeper and more pronounced with septum more distinct. **Hamilton:** Ont. (Arkona).

HADROPHYLLUM Edwards and Haime 1850

(**H. orbignyi*). Characterized by thick elevated corallum with calyx having four well developed fossulae and the base a conspicuous peduncle of attachment. **Dev., Miss.** (widespread in U. S. A.).

***H. orbignyi** E and H (**23**—24, 25). **M. Dev.:** Ind., Ky.

H. ovale Bassler (**23**—26–28). **Miss.** (Ft. Payne): Ky., Ala.

H. aplanatum Cummins (**23**—29, 30). **Penn.:** Tex. (Bend).

DIPTEROPHYLLUM Roemer 1883

(**Zaphrentis glans* White). Like *Hadrophyllum* except that peduncular point of attachment is much lengthened, giving corallum the aspect of a cup coral, and cardinal fossula is deeply incised with other three fossulae not well developed. **Miss.**

***D. glans** (White) (**23**—31–33). **Burlington:** Ia., Mo.

BARYPHYLLUM Edwards and Haime 1850

(**B. verneuilianum*). Upper surface like *Hadrophyllum*; flattened under side exposes septa over entire surface except for small, inconspicuous peduncular area. **Miss.**

***B. verneuilianum** E and H (**23**—34–37). **Miss.:** Tenn.

STREPTELASMA Hall 1847

(**S. corniculum*). "Form genus"; simple conical coralla, generally curved, with funnel-shaped calyx which generally is deep and furnished with numerous septa; longer septa in some species twisted at center to form a pseudocolumella; cardinal fossula present in later types; tetrameral arrangement of septa shown by their external ends; epitheca thin; interior with few dissepiments; tabulae rare or lacking. **Ord.–Dev.**

***S. corniculum** Hall (**24**—1–3). Corallum curved, calyx moderate, septa numerous and twisted at center. **Black River:** Ont. **Trenton:** Widespread in eastern and central N. America.

S. rusticum Billings (**24**—8–10). Larger than *S. corniculum* (62 to 87 mm = 2.5 to 3.5 in.); septa coarser and more strongly twisted, forming a vesicular pseudocolumella at center. **U. Ord.** (Richmond): Widespread and common throughout N. America.

S. petoskeyense Sloss (**24**—4–7). **M. Dev.:** Mich.

ENTEROLASMA Simpson 1900

(**Streptelasma* (*Petraia*) *stricta* Hall). Differs from *Streptelasma* in having pseudocolumella formed by projections from inner edges of septa, which edges in vertical section resemble intestinal convolutions. **Sil., Dev.**

E. caliculum Hall (**24**—11–13). Small, slender, uniformly tapering coralla with moderately deep calyx, comparatively few (20 to 50) septa separated by twice their width, thin epitheca, and costal grooves; septal ends united into a reticulate pseudocolumella. **Sil.** (U. Medinan and Niagaran): Que., Ont.; N. Y. to Ala., Ind., Wis.

***E. strictum** (Hall) (**24**—14–16). Corallum usually straight, simple, very gradually and regularly enlarging; exterior with strong growth undulations; costae strong, giving ribbed surface. **L. Dev.** (Helderbergian): Appalachian region (N. Y. to Tenn.), Okla.

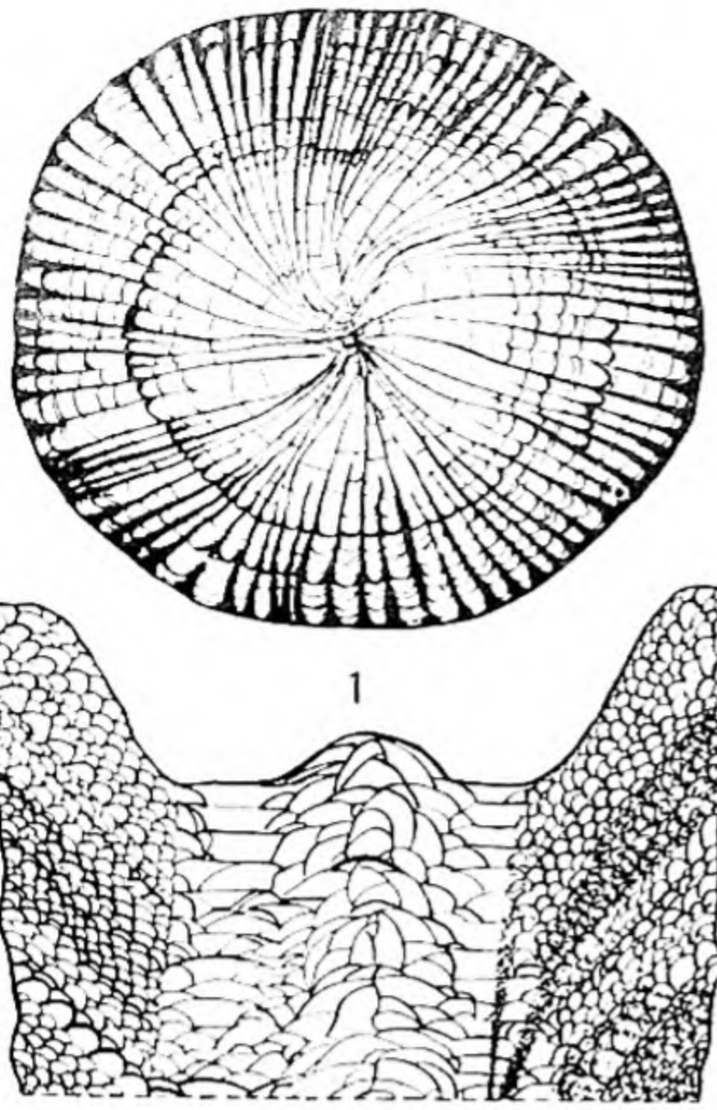
DUPLOPHYLLUM Koker 1924

(**Cyathophyllum? zaphrentoides* Etheridge). Cylin-

PLATE 28

[Figures are x1 unless otherwise indicated.]

1–6. Caninia spp. 1–3. C. juddi dawsoni [CGS, Contr Can Pal 4]. Exterior and sections of type. **4–6. C. torquia** [Mo G S 4]. Exterior and sections. **7–15. Heterophrentis spp. 7–11. H. prolifica.** Side and calicular views [Geol Can 1863]; calicular views of three specimens [Mich G S 3]. **12. H. simplex** [Pal N Y, Dev Corals]. **13–15. H. nevadensis** [JP 11]. Longitudinal and cross sections. **16, 17. Triplophyllum spinulosum** [Am Mid Nat 16]. Calicular and side views. **18–24. Homalophyllum spp. 18–22. H. ungula.** Calicular and two side views [Ind G S 12]; two other specimens [Mich G S 3]. **23, 24. H. calceolum** [Am Mid Nat 13]. **25, 26, 30, 31. Siphonophrentis gigantea.** Diagrammatic sections [CGS, Contr Can Pal 4]; calicular and lateral views of a large specimen (x0.5) [Mich G S 3]. **27–29. Diversophyllum traversense** (x1.3) [JP 13]. Cross and longitudinal sections of same specimen, and longitudinal section of another.



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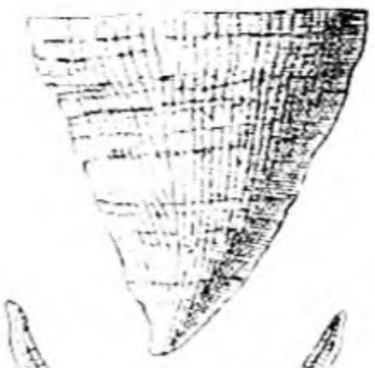

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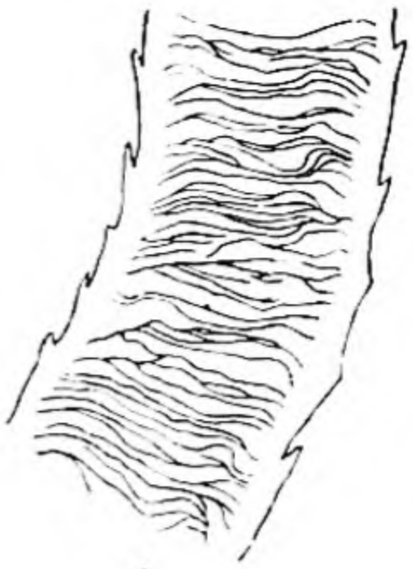

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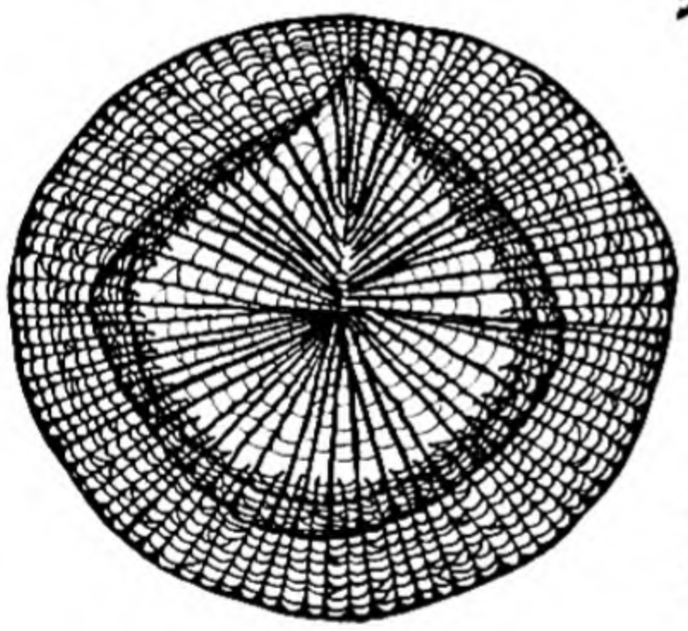

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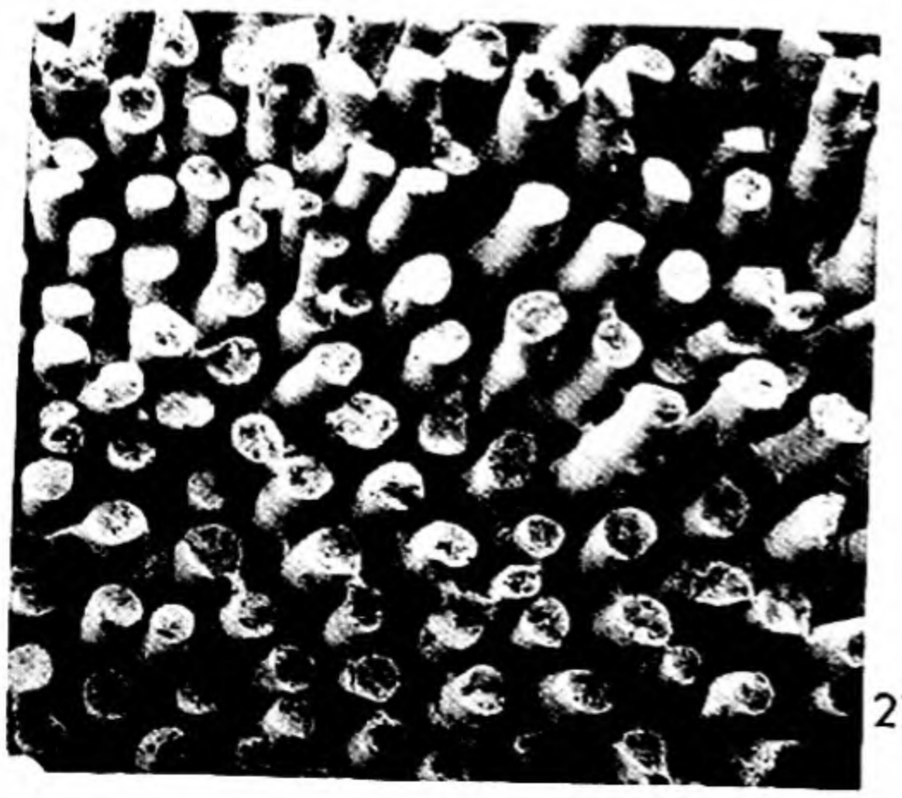

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drical small to medium-sized corals having numerous subequal major septa that reach axis in young stages but not in adult; somewhat long, slender, generally flexuous secondary septa which tend to unite distally with an adjacent major septum; tabulae thin, arched upward gently; dissepiments not observed. **Perm.** (N. America; Australia; Timor).

D. septarugosum Moore and Jeffords (**24**—21–24). Strongly flexuous minor septa and irregularly thickened major septa; well-defined calicinal budding. **M. Perm.** (Leonard): Glass Mts., W. Tex.

STEREOLASMA Stimson 1900

(**Strombodes? rectus* Hall = *Streptelasma rectum* Hall (in part)). Corallum simple, straight or curved; calyx circular; fossulae conspicuous; septa alternating in size, the major ones extending to center, straight or very slightly twisted; there is a pseudocolumella formed by stereoplasmic binding together of inner ends of septa. **Dev.**

***S. rectum** (Hall) (**24**—17–20). Surface strongly wrinkled and irregular because of strong epitheca. **Hamilton:** N. Y. to Md.

HAPSIPHYLLUM Simpson 1900

(**Zaphrentis calcariformis* Hall = *Z. cassedayi* Milne-Edwards). Corallum simple, small, conical, with an elongate or horseshoe-shaped inner wall opening on side of cardinal fossula; tabulae and dissepiments present. **Miss.**

***H. calcariforme** (Hall) (**24**—25–27). **Meramec** (Salem): Ind., Ky.

LOPHOPHYLLIDIUM Grabau 1928

(= LOPHOPHYLLUM of most American authors)

(**Cyathaxonia prolifera* McChesney). Small to medium-sized, solitary conical corals, straight or curved; septa 30 to 50, alternating in length; theca longitudinally grooved; calyx moderately deep, bearing a laterally compressed, generally solid columella that projects prominently; thin up-arching tabulae extend from wall to wall; dissepiments not observed. **Penn., Perm.** (N. America; China; ?U. S. S. R.).

***L. proliferum** (McChesney) (probably = **Lophophyllum profundum** Edwards and Haime of many American authors) (**25**—1–7). **Penn.:** Widespread and common in the Mississippi Valley to Tex. and N. Mex.; Alta. **Perm.:** Ariz. (Kaibab).

L. dunbari Moore and Jeffords (**25**—8–11). Nearly straight corals of medium size; major septa 19 to 25 in adult stage; a conspicuous open fossula is formed by reduction of cardinal septum; columella proportionately smaller than in preceding. **L. Perm.** (Wolfcamp); Kan. (Beattie).

MALONOPHYLLUM Okulitch and Albritton 1937 (**M. texanum*). Like *Lophophyllidium*, but tabulae lacking. **L. Perm.** (Wolfcamp) to lower **M. Perm.** (Leonard) (Kan., Tex.).

M. kansasense Moore and Jeffords (24—28–31). Small, steeply conical solitary corals slightly curved in plane of alar septa; major septa 20 to 24, much shortened near calyx; counter septum not extended in adult stage; prominent solid columella. **Wolfcamp:** Kan. (Beattie).

***M. texanum** O and A. Major septa 40, not greatly reduced near calyx, deflected strongly toward counter septum. **Leonard:** Malone Mts., W. Tex.

LOPHAMPLEXUS Moore and Jeffords 1941

(**L. eliasi*). Youthful stages like *Lophophyllidium* columella lacking in mature stages where tabulae and short septa resemble those of *Amplexus*. **L. Perm.** (Wolfcamp) (Kan., Okla.).

***L. eliasi** M and J (**25**—14–19). Corals of medium size, about 27 major septa; cardinal fossula present except in fully mature stage. **Wolfcamp:** Kan. (Foraker, Beattie), Okla. (Foraker).

HERITSCHIA Moore and Jeffords 1941

(**H. girtyi*). Conico-cylindrical corals of medium size growing in loosely packed colonies; strong septal grooves on theca; major septa evenly disposed, obliquely fluted, not reaching axial column, which is laterally compressed, solid or bearing a few radial lamellae; widely spaced tabulae in central region and abundant dissepiments in peripheral zone. **L. Perm.**

***H. girtyi** M and J (**25**—12, 13). **Wolfcamp:** Kan. (Florence).

H. columbica (Smith) (**25**—29). Differs from *H. girtyi* in smaller size, less thickened column, and lack of a distinct septal stereozone. **?L. Perm.:** B. C.

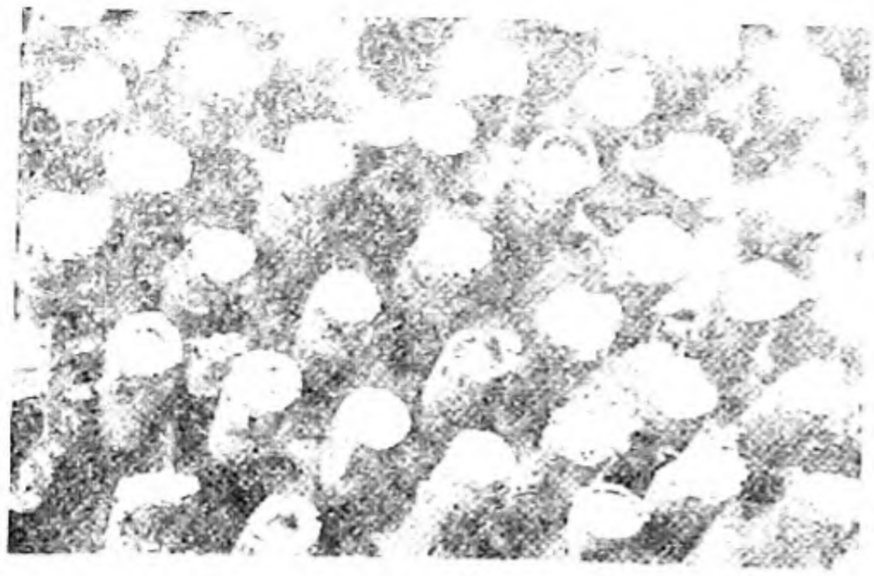
DIBUNOPHYLLUM Thomson and Nicholson 1876

(**D. muirheadi*). Corallum simple, conical; epitheca complete, thin, annulated; calyx shallow, with central boss which is separated into two equal parts by a mesial line; primary septa do not reach central area and secondary ones short or wanting; dissepiments abundant in peripheral zone only; tabulae present; similar to *Clisiophyllum* in many structural features. **Carb.** (U. S. A.; Europe).

PLATE 29

[Figures are x1 and after Lambe [CGS, Contr Can Pal 4] unless otherwise indicated.]

1, 2. Tortophyllum cysticum [JP 13]. Diagrammatic sections enlarged about x1.2. **3–5. Lambeophyllum profundum.** Top and side views and longitudinal section. **6–18. Amplexus** spp. **6–8. A. shumardi.** Sections and exterior. **9, 10. A. hamiltoniae** [NAIF]. **11–13. A. yandelli.** Exterior and sections. **14, 15. A. nevadensis** [JP 11]. Cross and longitudinal sections. **16–18. A. corrugatus** [DUB, JSL 18]. Two corallas and a cross section. **19. Hallia vesiculata** (x1.3) [JP 13]. **20, 21. Cyathophyllum robustum** [GSA, SP 8]. **22, 23. Disphyllum occidens** [JP 12]. Cross section of several corallites and a longitudinal section. **24. Grypophyllum giganteum** [JP 11]. **25–28. Synaptophyllum multicaule,** Diagrammatic sections (x2); top and side views of part of a corallum [Mich G S 3].



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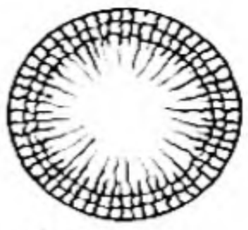

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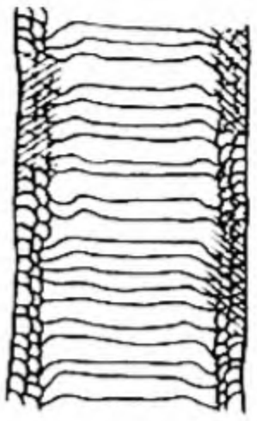

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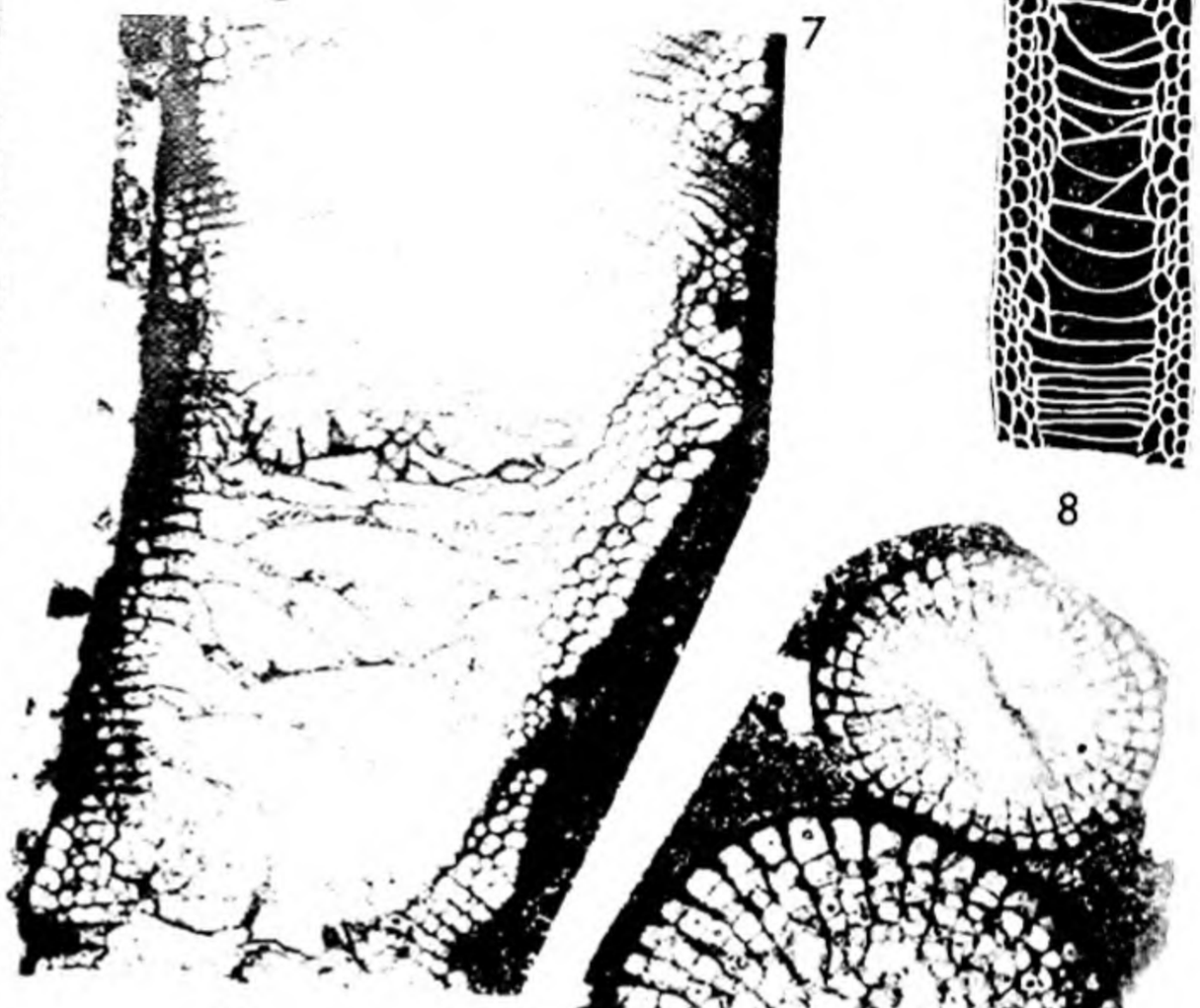

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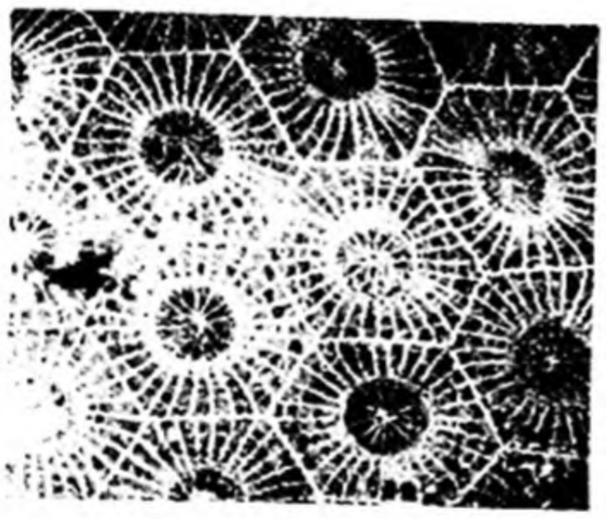

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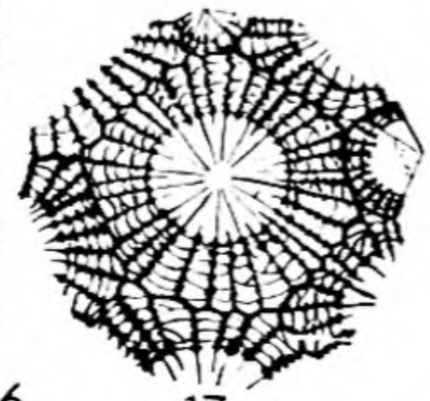

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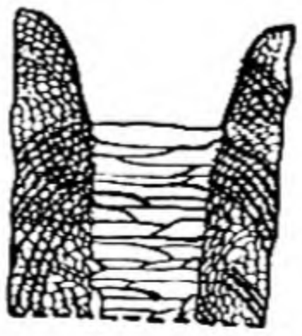

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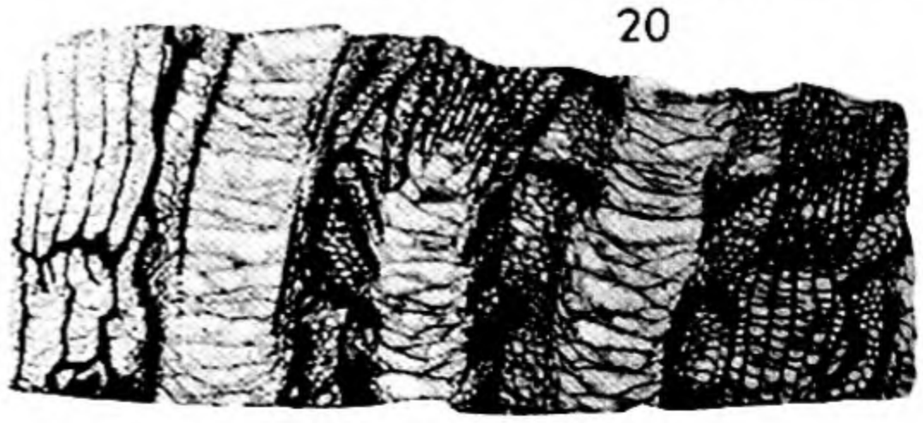

D. valeriae Newell (**25**—23–25). **Penn.:** Kan. (Eudora).

AXOPHYLLUM Edwards and Haime 1850

(? = LONSDALEIA McCoy 1849, or CARCINOPHYLLUM Thomson and Nicholson 1876)

(**A. expansum*). Corallum simple, turbinate, with complete epitheca; axis occupied by a large, strong cylindrical columella composed of numerous vertical, spirally twisted lamellae; zone between columella and peripheral wall occupied by dissepiments and coarsely vesicular; septa well developed, extending to center of visceral chamber. **Penn.:** (central U. S. A.).

A. rude White and St. John (**25**—20–22). **Penn.:** Ind. (W. Franklin), Kan.

WAAGENOPHYLLUM Hayasaka 1924

(**Lonsdaleia indica* Waagen and Wentzel). Colonial rugose corals, generally fasciculate and consisting of small, closely packed, cylindrical corallites; major septa subequal, slightly wavy, persisting to theca; peripheral zone of dissepiments prominent; tabulate zone narrow; axial column formed by arched tabellae and few radiating lamellae; column joined to counter septum; differs from *Heritschia* chiefly in nature of septa. **M.** and **U. Perm.** (the genus is an index fossil throughout the world).

W. texanum Heritsch (**25**—30). Corals unusually large for genus; axial column very prominent, rather dense. **Guadalupe:** W. Tex. (Altuda).

LEONARDOPHYLLUM Moore and Jeffords 1941

(**L. distinctum*). Conico-cylindrical solitary corals; theca not marked by distinct septal grooves; major septa evenly disposed, subequal except for shortened cardinal septum; a prominent columella intersects numerous tabulae that have steeply conical form; dissepiments absent. **M. Perm.** (W. Tex.).

***L. distinctum** M and J (**25**—26–28). Distinguished by even slope of tabulae. **Leonard:** W. Tex.

L. acus M and J (**26**—1–3). Tabulae subvertical in axial region. **Leonard:** W. Tex.

LITHOSTROTION Fleming 1828

(**L. striatum*). Colonial coralla composed of prismatic or cylindrical corallites, each enveloped by an epitheca and all by peritheca; central portion occupied by tabulae which are inverted funnel-shaped, terminating in the calyx in a columella; septa well developed; outer area with numerous dissepiments. **Miss., Penn.**

"L." proliferum Hall (**26**—6–8). **M. Miss.** (St. Louis): Ill.

"L." whitneyi Meek (**26**—4, 5) **Miss.:** Mont., Idaho, Utah, Nev. **Penn.:** (Rundle): western Canada.

LITHOSTROTIONELLA Yabe and Hayasaka 1915

(= LITHOSTROTION and LONSDALEIA of American authors)

(**L. unicum*). Corallum composite, massive, composed of prismatic corallites with lamellar columella; distinguished from *Lithostrotion* by a vesicular peripheral zone, well bounded by an inner wall, the inside of which has essentially the same structure as *Lithostrotion*; septa protruding out of inner wall soon disappear in vesicular zone, without extending to wall. **Miss.**

L. castelnaui Hayasaka (**26**—9–12). Corallum composite, massive, very large; corallites long, prismatic; calices variable in size, larger more than 25 mm across; central columellar projection; septa abundant, not quite reaching center; cardinal fossula often apparent at one end of columellar projection. **Miss.:** Va., W. Va., Ala., Ky., Ill., Mo. (This is the common "*Lithostrotion*" which is the characteristic fossil of the mid-Mississippian throughout the eastern two-thirds of the U. S. A.)

L. hemisphaerica Hayasaka (**26**—15–17). Structurally like *L. castelnaui*, but it is smaller, hemispherical, has smaller calices, and more septa and tabulae. **Miss.:** Va., W. Va., Ky., Tenn., Ill., Mo., Idaho, Utah.

L. americana Hayasaka (**26**—13, 14). Differs from two preceding in its prismatic growth, well defined peripheral zone and consequently false inner wall, fewer septa (22 to 28), and somewhat simpler structure. **Miss.** (St. Louis): Ky., Ill., Mo., Idaho, Cal.; Alaska.

ERIDOPHYLLUM Edwards and Haime 1850

(**E. seriale* = *E. verneuilianum*). Compound rugose corals typically phaceloid, with axial edges of major septa bent at right angles and fused to form a tube or *aulos*; septa thin, carinate, with carinae on the two sides of septa in line; tabulae, divided by the aulos into an axial and periaxial series, are horizontal and widely spaced; dissepiments globose, fine, numerous. **Dev.**

***E. seriale** E and H (**27**—1–5). Characterized by widely separated corallites united by strong lateral

PLATE 30

[Figures are x1 unless otherwise indicated.]

1–7. Synaptophyllum spp. 1–4. S. simcoense. Top and side views of a corallum [Mich G S 3]; diagrammatic sections of a corallite (x2) [N Y St Mus, B 39]. **5–7. S. arundinaceum** [CGS, Contr Can Pal 4]. Part of a corallum and sections enlarged (x2). **8–10, 15. Cylindrophyllum spp. 8. C. elongatum** [N Y St Mus, B 39]. Diagrammatic longitudinal section (x1.3). **9, 10. C. panicum** [U Mich, Contr Mus Pal 4]. Enlarged sections (x4). **15. C. hindshawi** [U Mich, Contr Mus Pal 4]. A complete corallum (x0.5). **11–14, 16–20. Hexagonaria spp. 11, 12. H. prisma** [GSA, SP 8]. Sections showing structure of corallites (x2). **13, 14. H. parvula** (x2) [JP 14]. **16–18. H. percarinata** [JP 13]. Surface of corallum (holotype) and diagrammatic sections (x2). **19, 20. H. anna** (x2) [GSA, SP 8].

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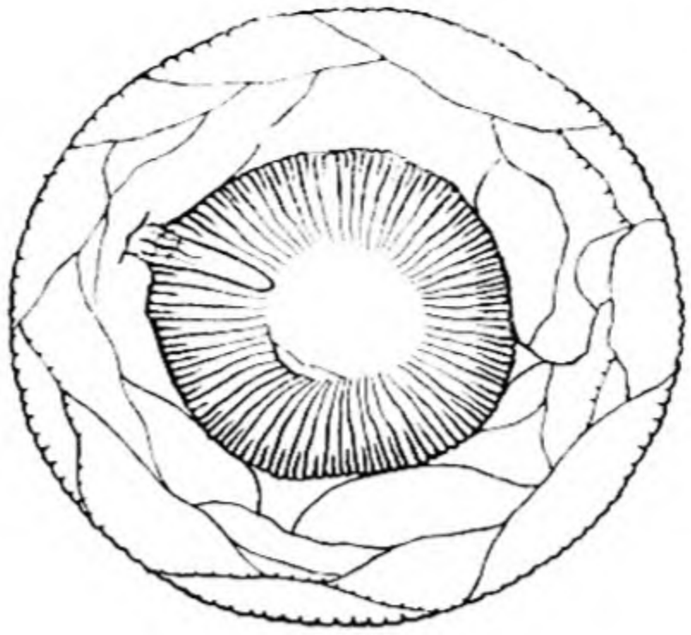

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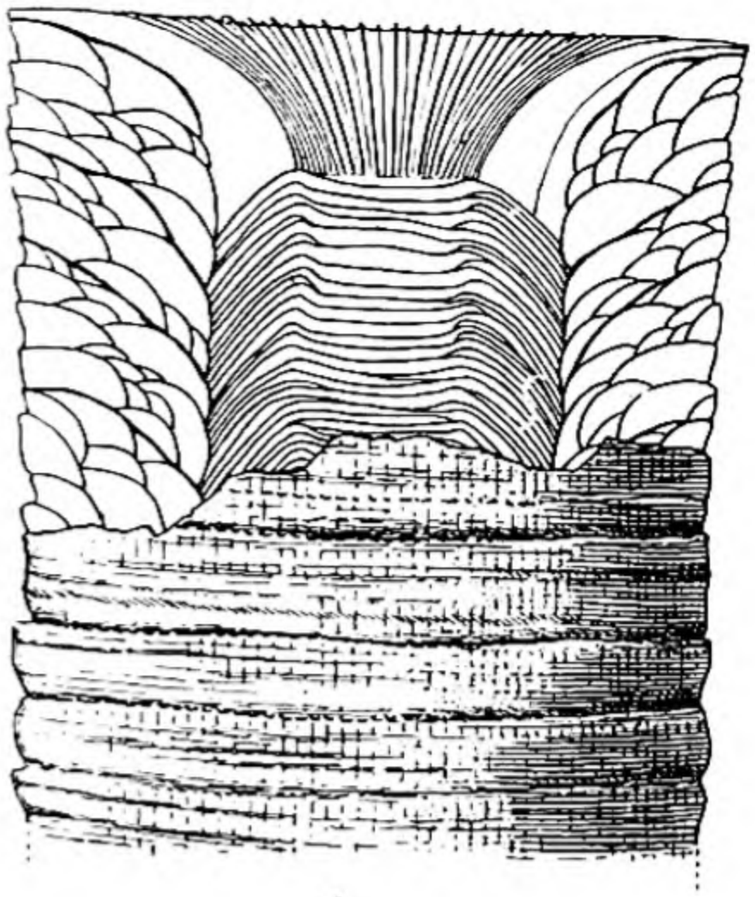

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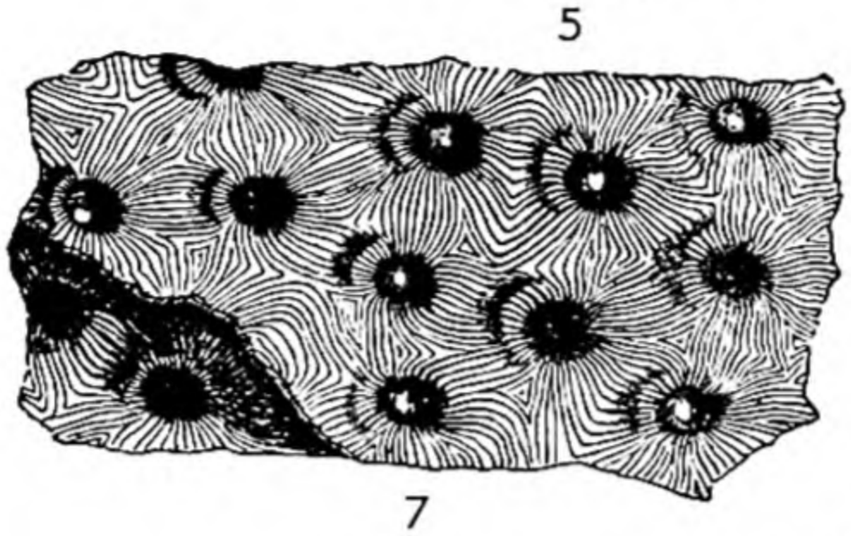

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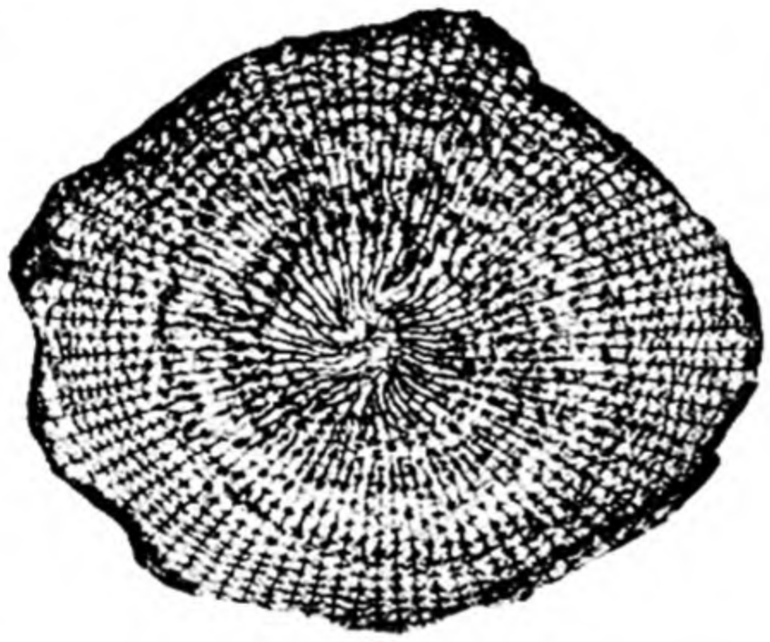

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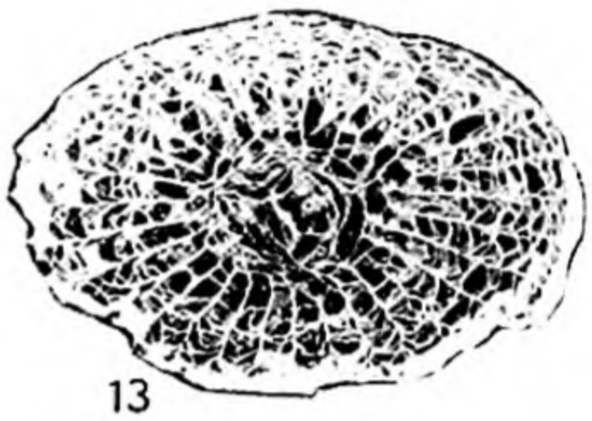

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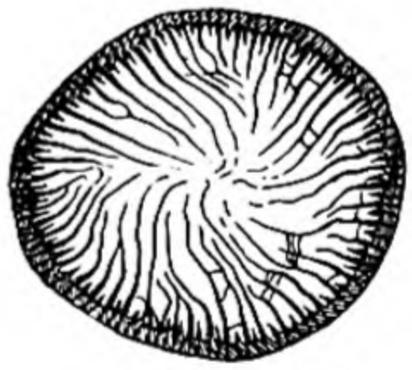

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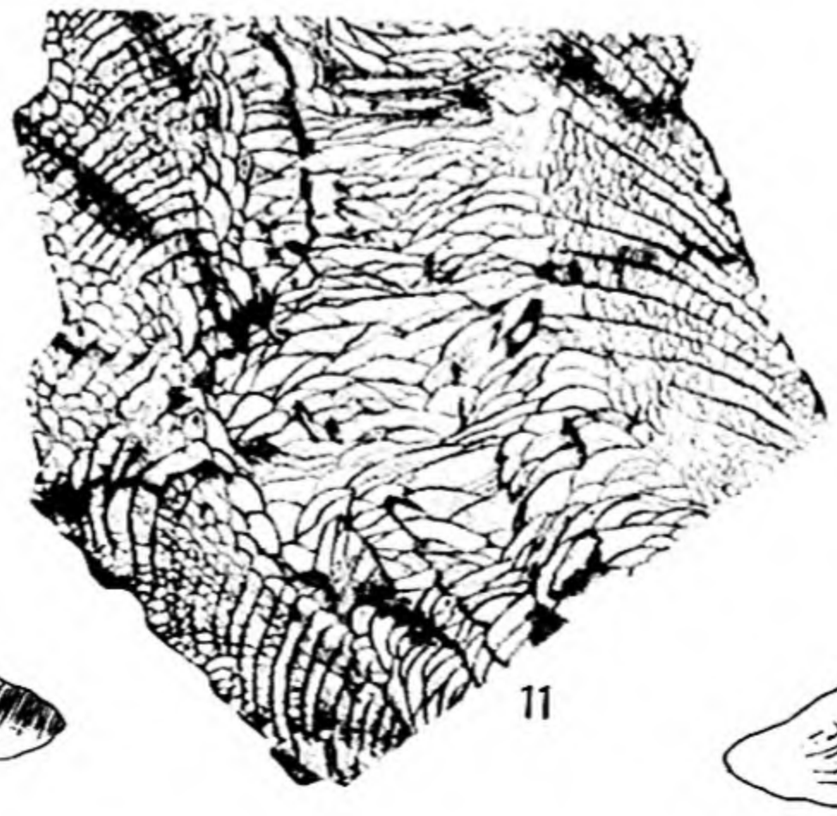

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outgrowths. **Onondaga:** Ont.; Mich., Ohio (Columbus). **Hamilton:** Ky. (Sellersburg).

E. colligatum (Billings) (**27**—6–10). Outgrowths from corallites occur at same level in adjacent corallites and meet to form successive platforms at which levels the corallites are prismatic; elsewhere they are cylindrical. **Onondaga:** Ont.; Mich., Ky. (Falls of Ohio).

E. archiaci (Billings) (**27**—11–14). Corallites usually touching, without outgrowths, sometimes becoming prismatic from crowding; diameter 10 to 20 mm; inner wall horseshoe-shaped. **Hamilton:** Ont.; N. Y., Mich. (Traverse), Ind., Ky.

ZAPHRENTIS Rafinesque and Clifford 1820

(**Z. phrygia* R and C = *Caryophyllia cornicula* Leseur (*partim*)). Simple, elongated corallum, surrounded completely by an epitheca; calyx deep; a single, well developed fossula marking abortion of cardinal septum; no columella; numerous well developed, serrate septa with carinae in typical species; tabulae imperfect or absent; septa prolonged generally to center of visceral chamber. (*Heliophrentis* Grabau 1910 (**H. alternata*) has been proposed for Silurian zaphrentids characterized by carinae, but it is not generally recognized as a valid genus.) **Sil.–Miss.**

***Z. phrygia** R and C (**27**—15–17). Corallum a curved cone with deep calyx, well marked fossula, carinated septa and without tabulae. **M. Dev.** (Onondaga): Ont.; N. Y., Mich., Ohio (Columbus), Ind. (Jeffersonville), Ky. (Falls of Ohio), Wis.

NEOZAPHRENTIS Grove 1935

(**Zaphrentis tenella* Miller). Zaphrentoid corals with rugose or annulated exterior, noncarinate septa that are usually straight, variable in thickness, and in primary and secondary cycles, the latter sometimes rudimentary; not more than 60 major septa, which extend to calyx center where they may fuse, or failing to reach center end at a small open or tabulate area; cardinal fossula conspicuous; tabulae few or numerous; dissepiments few, unzoned; no columelloid structure from fusion of septa; Grove states that this characterization is essentially that of *Zaphrentis sl.*, and expresses the hope that this new genus will serve as "a taxonomically sound repository for large numbers of congeneric species now termed '*Zaphrentis.*'" **Sil.–Penn.**

N. racinensis (Whitfield) (**27**—21, 22). **Niagaran:** N. Y. (Guelph), Wis. (Racine).

***N. tenella** (Miller) (**27**—18–20). **L. Miss.:** Mo. (Chouteau).

N. wannensis (Newell) (2, —28–26). **Penn.:** Okla. (Lansing).

CANINIA Nicholin 1880

(**C. cornucopiae*). Simple rugose corals, either trochoid or cylindrical, in adults of which septa do not reach axis; cardinal fossula typically conspicuous; tabulae usually broad and convex; dissepiments present. **Dev., Miss.** (worldwide).

C. juddi dawsoni (Lambe) (2a—1–3). **Miss.** (Viséan): N. S. (U. Windsor).

C. torquia (Owen) (= **Campophyllum torquium** of authors) (**28**—4–6). Cylindrical, often very long (20 to 25 cm, 8 to 9 in.), and abruptly bent; epitheca very thin, generally denuded; calyx deep with moderate fossula; principal septa extending half to two-thirds distance to center, tertiary ones very short. **L. Penn.:** Ark., Okla.; Alta. **Penn.:** Ill., Neb. to Tex. (Gaptank).

HETEROPHRENTIS Billings 1875

(**Zaphrentis prolifica* = *Z. spatiosa* Billings). Corallum zaphrentoid with large calyx bottomed by a single flat tabula which has a central low rounded elevation; septa alternating in size, sharp-edged below calyx and often with inner edges twisted together. **Dev.**

***H. prolifica** (Billings) (**28**—7–11). Conical and generally curved, expanding rapidly; septa meet at center of deep calyx, where frequently they are spirally twisted; fossula conspicuous, deep, variable in position. **Dev. Onondaga:** Ont.; Mich., Ohio (Columbus), Ky. **Hamilton:** Ont.; Mich.

H. simplex (Hall) (**28**—12). Distinguished by its slender appearance, irregular septa, and apparently shallow calyx. **Hamilton:** Ont.; N. Y., Mich., Ohio.

H. nevadensis Stumm (**28**—13–15). **M. Dev.:** Nev. (Nevada).

HOMALOPHYLLUM Simpson 1900,
emend Grove 1935

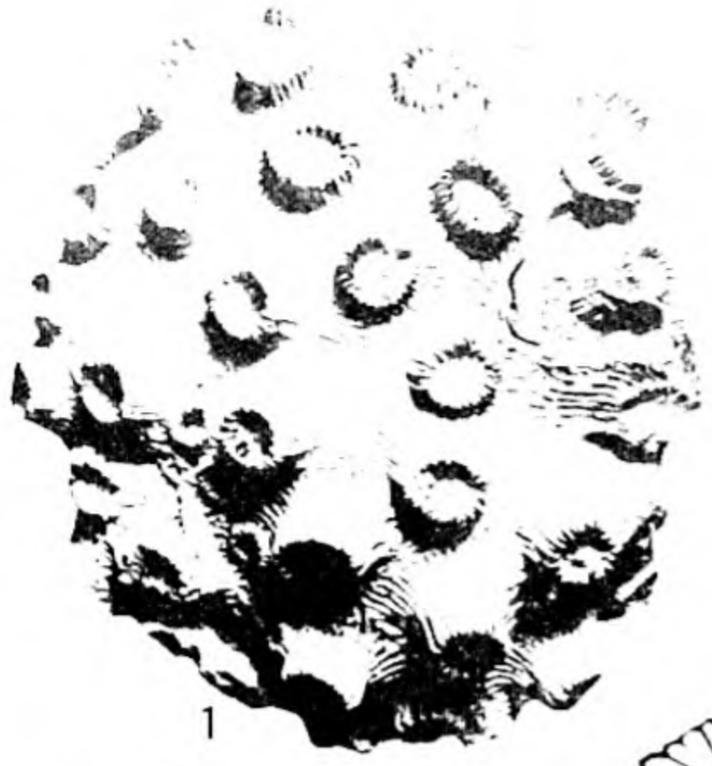
(**Zaphrentis ungula* Rominger). Corallum cornute, but asymmetrically flattened on cardinal (convex) side; calyx suboval to round; septa well developed, primary ones reaching to calyx center; cardinal fossula large, extending to calyx center on convex side; tabulae and dissepiments present. **Dev., Miss.**

***H. ungula** (Rominger) (**28**—18–22). Corallum compressed dorsoventrally; cardinal septum in center of flat side; long diameter of calyx about twice short diameter; septa 90 to 100, serrate, rarely carinate; fossula marked at calyx margin. **Onondaga:** Ont.; Mich. ("Drift"), Ind., Ky.

PLATE 31

[Figures are x1 unless otherwise indicated.]

1–4 Tabulophyllum rectum [U Mich, Contr Mus Pal 1]. Section and exterior of a paratype, and sections of holotype. **5, 6. Blothrophyllum decorticatum** [CGS, Contr Can Pal 4]. **7. Billingsastraea verneuili** [Geol Can 1863]. **8–11. Hellophyllum halli.** 8: Complete specimen [Pal N Y, Dev Corals]; 9, 10: Cross and longitudinal sections [GSA, SP 8]; 11: Longitudinal section (x1.6) [Carnegie Mus, An 27]. **12–14. Paleosmilia schucherti** [AJS (5) 32]. Complete corallum, and sections enlarged (x1.5). **15–17. Ptychophyllum stokesi** [CGS, Contr Can Pal 4].



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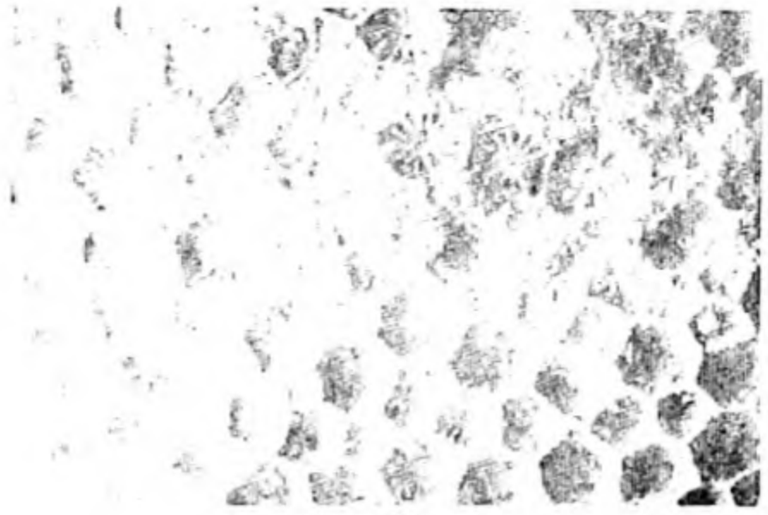

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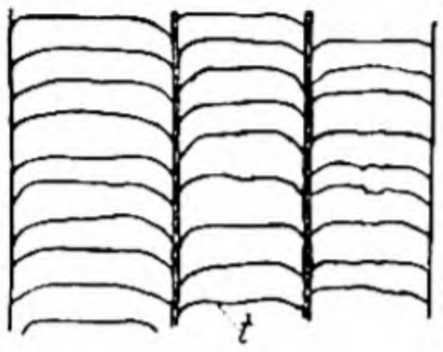

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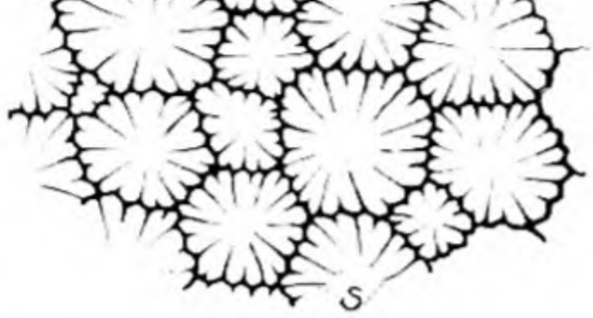

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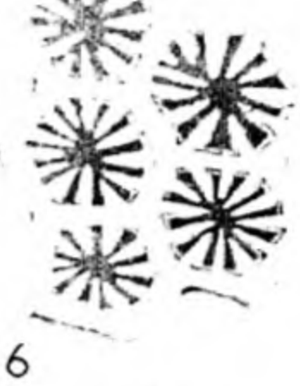

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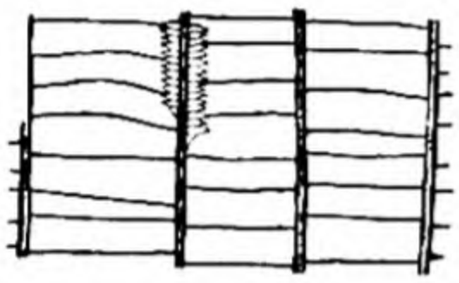

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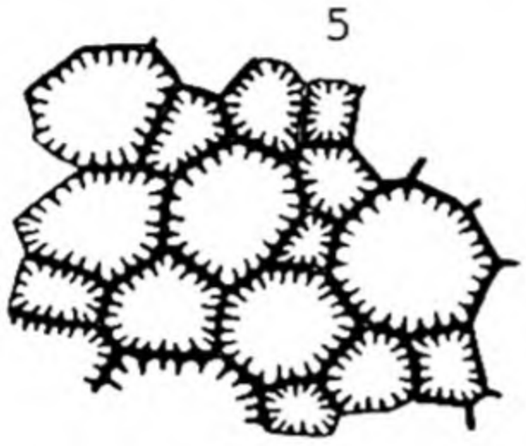

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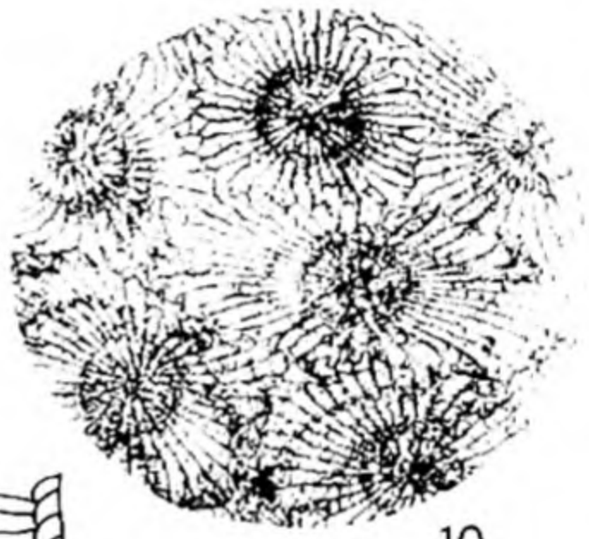

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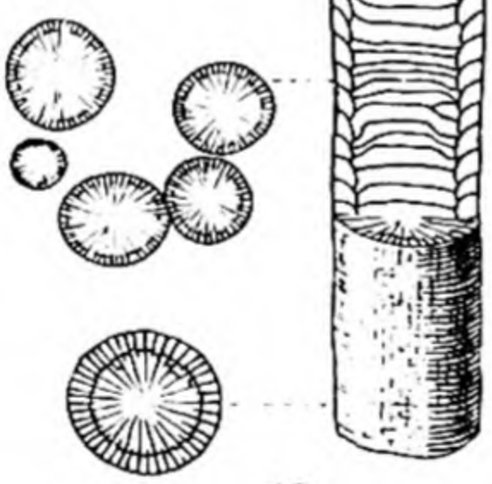

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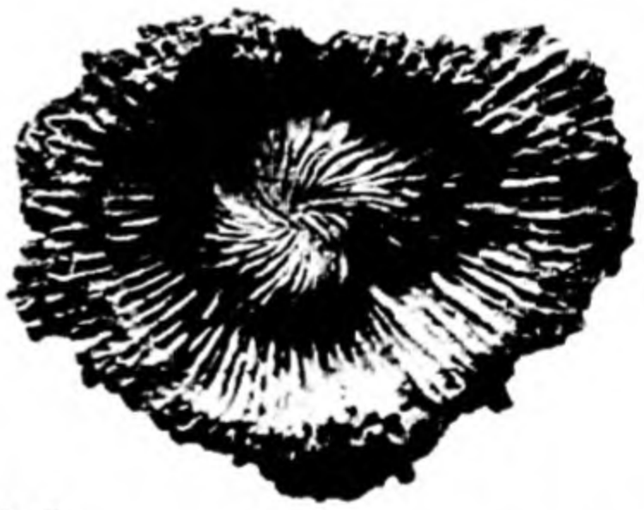

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H. calceolum (White and Whitfield) (**28**—23, 24). **Miss.:** Mo. (Chouteau).

TRIPLOPHYLLUM Simpson 1900

(**Zaphrentis terebrata* Hall). Zaphrentoid, with well developed alar fossulae; calcareous fibers of septa arranged obliquely inward or toward center of corallum. **Dev., Miss.**

T. spinulosum (Edwards and Haime) (**28**—16, 17). **Kinderhook–U. Chester:** Ill., Ia., Mo., Ark.

SIPHONOPHRENTIS O'Connell 1914

(**Caryophyllia gigantea* Lesueur = *Zaphrentis gigan-teum*). Zaphrentoid, but having well developed tabulae extending across corallum and bending down marginally and, on each side of cardinal septum, forming a series of invaginated funnels giving a siphono-fossula; no external vesicular zone. **Dev.**

***S. gigantea** (Lesueur) (**28**—25, 26, 30, 31). Generally large, becoming cylindrical in adult; length as much as 75 cm (2.5 ft.) with a diameter of 75 mm (3 in.); bottom of calyx shows a tabula, septa not reaching the center; fossula large and deep; epitheca strongly wrinkled; tabulae numerous, crowded. **Onondaga:** Ont.; N. Y., Mich., Ohio (Columbus), Ky. (Falls of Ohio).

DIVERSOPHYLLUM Sloss 1939

(**Zaphrentis traversensis* Winchell). Cylindrical or ceratoid, simple rugose corals with long, unornamented septa, and vertically elongate concentric dissepiments; tabulae flat or domed. **Dev.**

***D. traversense** (Winchell) (**28**—27–29). **Hamilton:** Mich. (Alpena), Ia. (Cedar Valley); Hay River, NWT, Canada.

TORTOPHYLLUM Sloss 1939

(**Zaphrentis cystica* Winchell). Solitary rugose corals with numerous steeply inclined rows of globose dissepiments, tabulae differentiated into a horizontal periaxial series, and an inclined axial series, which is reflected in the calyx by a low calicular boss; major septa extend to axis, where they are somewhat twisted; minor septa characteristically long; corallum lacks symmetry and a cardinal fossula. **Dev.**

***T. cysticum** (Winchell) (**29**—1, 2). **M. Dev.:** Mich. (Gravel Pt., Alpena).

LAMBEOPHYLLUM Okulitch 1938

(**Cyathophyllum profundum* Conrad). Corallum simple, conical, small; epitheca complete; calyx deep, at times reaching almost to base of corallum; septa little developed, tetrameral arrangement indicated by septal furrows on the surface; cardinal and two alar septa may be conspicuous; septal fossula may be present; tabulae, dissepiments, and columella absent; first pairs of secondary septa added simultaneously in cardinal and counter quadrants, and septa lacking altogether in very earliest stages. **M. Ord.** (eastern N. America).

L. profundum (Conrad) (**29**—3–5). **Black River:** Eastern N. America.

AMPLEXUS Sowerby 1814

(**A. coralloides*). Generally cylindrical or conico-cylindrical corallum, with structure much like *Zaphrentis*, but with septa secondarily shortened, reaching only a short way out onto the well developed horizontal tabulae; fossula well characterized in upper portion of corallum, but not so on lower tabulae; tabulae well developed. **Sil.–Miss.**

A.? shumardi (Edwards and Haime) (**29**—6–8). Subcylindrical, with numerous regular constrictions all covered with thin epitheca; fossula well developed. **Sil. Medinan:** Ont. (Cataract). **Niagaran:** Mich., Ky., Tenn., Wis., Ia.

A. yandelli (Edwards and Haime) (**29**—11–13). Irregularly cylindrical, often bent, constriction irregular; tabulae more or less irregular; septa short, numbering 80. **M. Dev.** (Onondaga): Ohio (Columbus), Ind., Ky.

A. hamiltoniae Hall (**29**—9, 10). Small, cylindrical, often abruptly bent and constricted; strong distant septa reach about a third of way toward center, then stop abruptly. **M. Dev.** (Hamilton): Ont.; N. Y., Md., Mich.

A. nevadensis Stumm (**29**—14, 15). **M. Dev.:** Nev. (Nevada).

A. corrugatus Mather (**29**—16–18). **Penn.:** Okla. (Morrow).

HALLIA Edwards and Haime 1850

(**H. insignis*). Like *Aulacophyllum*, except for the long cardinal septum. **Dev.**

H. vesiculata Sloss (**29**—19). **M. Dev.:** Mich. (Petoskey, Potter Farm).

CYATHOPHYLLUM[1] Goldfuss 1826

(**C. dianthus*). "Form genus"; corallum simple, rarely becoming compound in more specialized

[1] G. M. Ehlers (personal communication) believes that "numerous American species assigned to *Cyathophyllum* must belong to many different genera," and G. A. Stewart (1938, 32) discusses the need for a thorough revision of this "form genus," especially in its relation to *Heliophyllum*.

PLATE 32

[Figures are x1 unless otherwise indicated.]

1, 2. Pachyphyllum woodmani [U Mich, Contr Mus Pal 1]. Upper and lower surfaces of a corallum. **3–9. Favistella spp. 3, 8, 9. F. halli.** Surface [Tenn G S, B 38]; diagrammatic sections (x2.5) [CGS, Contr Can Pal 4]. **4, 5. F. alveolata** [CGS, Contr Can Pal 4]. **6, 7. F. stellata** [Pal N Y 1]. **10. Billingsastraea billingsi nevadensis** [JP 11]. **11, 12. Diplophyllum caespitosum.** Fragmental corallum [Pal N Y 2]; diagrammatic sections (x2) [CGS, Contr Can Pal 4]. **13. Acrophyllum oneidaense** [CGS, Contr Can Pal 4]. **14–16. Entelophyllum rugosum** [AJS (5) 26]. Sections (x2.5) and incomplete corallum. **17, 18. Calceola (Rhizophyllum) tennesseensis** [NAIF]. Side and top views. **19, 20. Ptychophyllum stokesi** [Mich G S 3; photographs furnished by G. M. Ehlers]. Top and side views of a weathered corallum.

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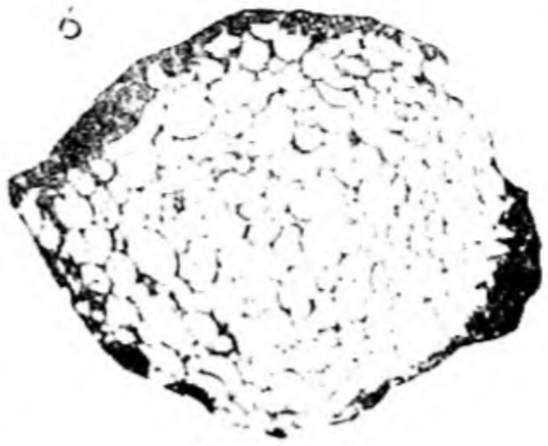

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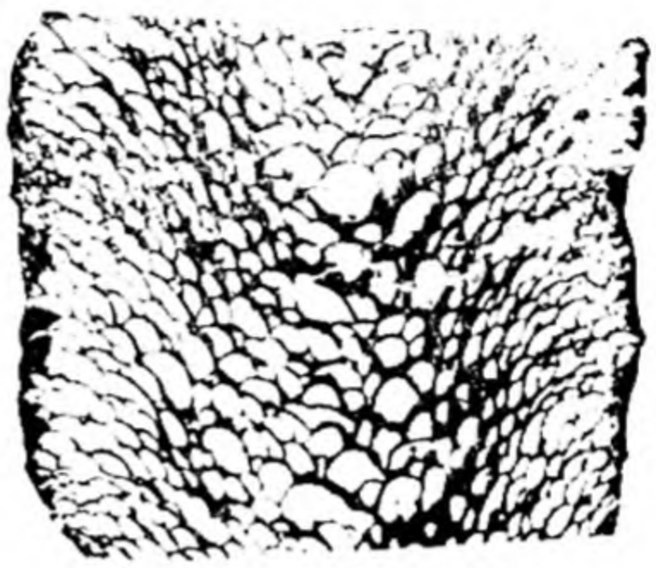

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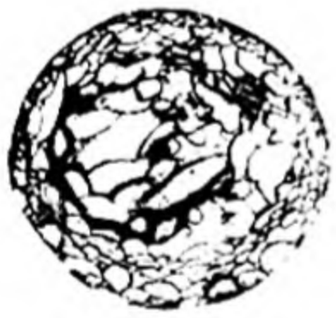

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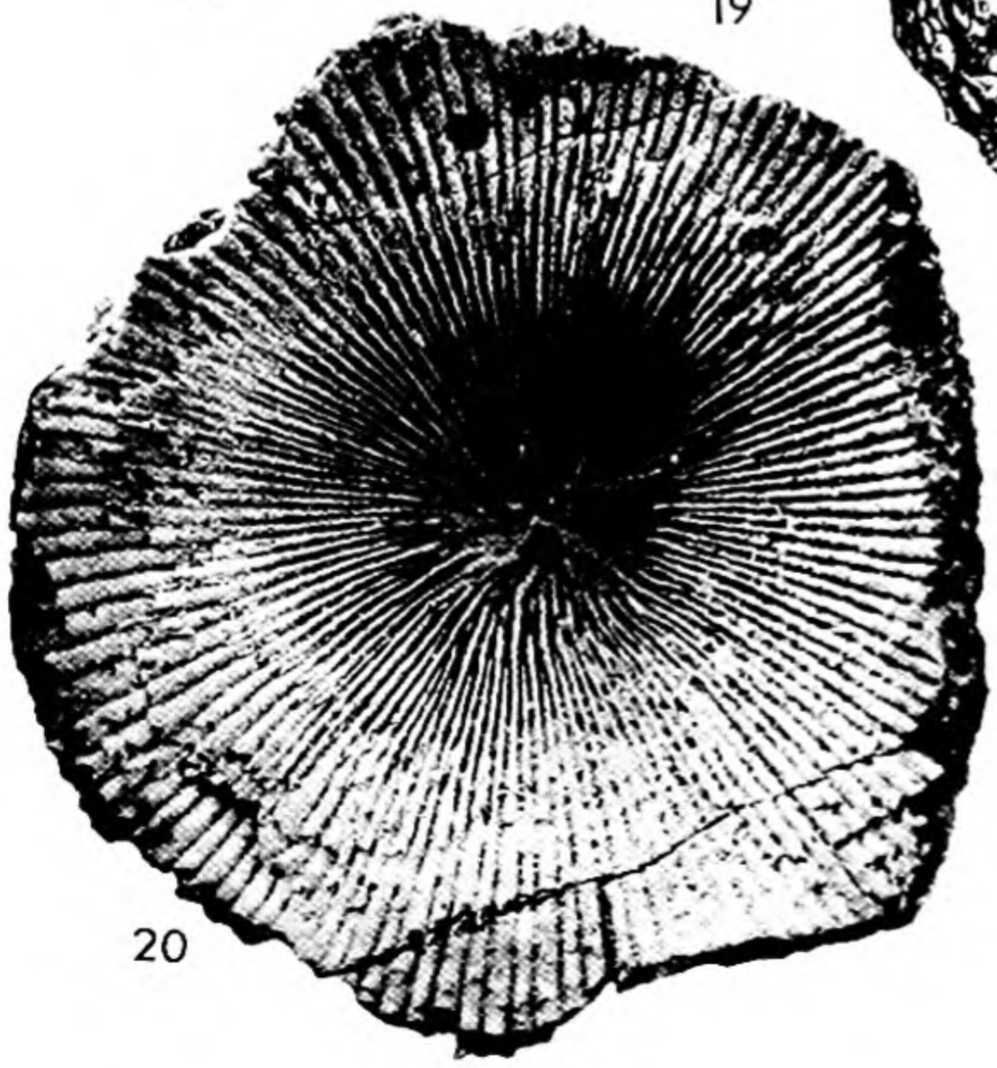

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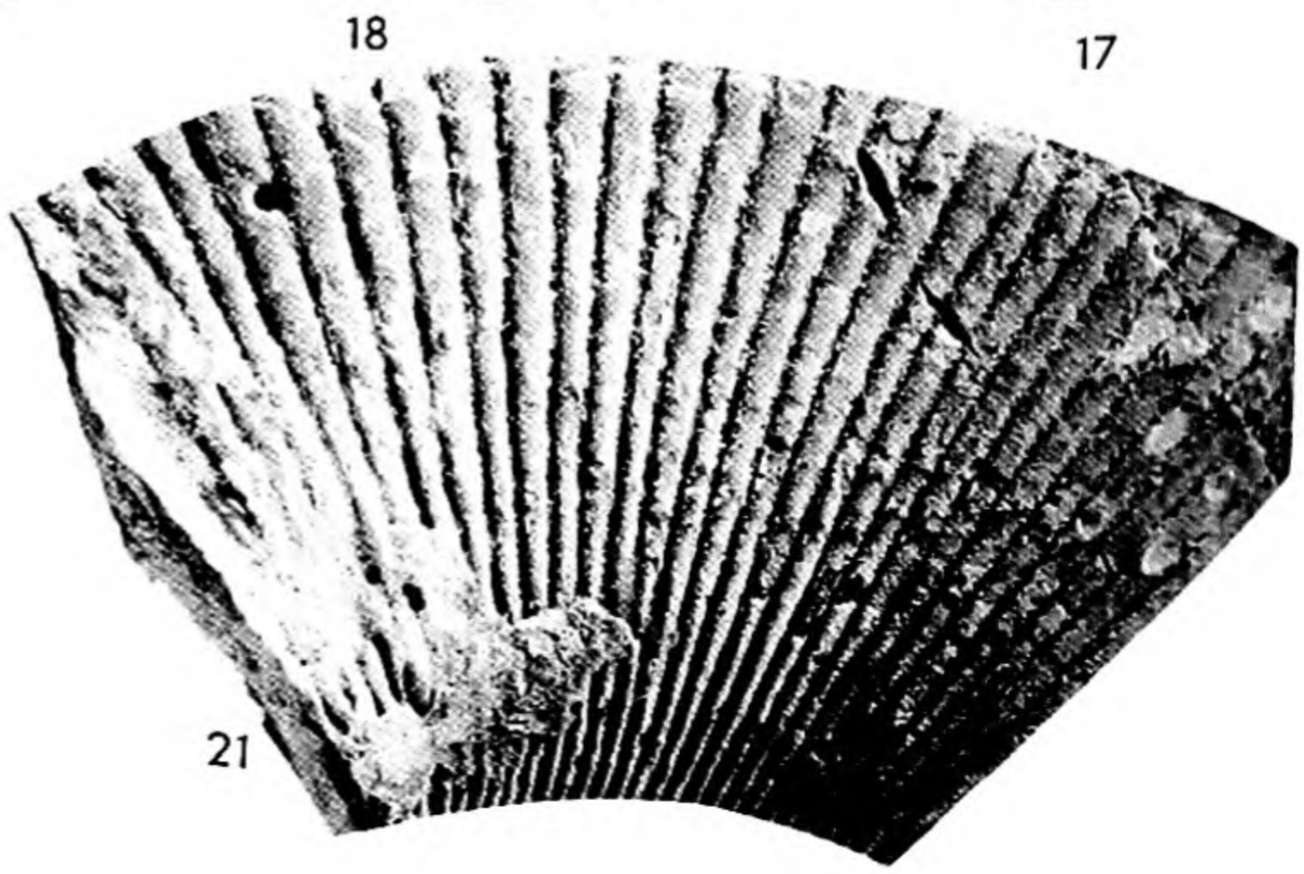

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types; corallites conical, generally cylindrical in later growth stages; septa simple, noncarinate, extending to center of calyx, where they are more or less twisted; fossulae indistinct or lacking; tabulae confined to central area; dissepiments numerous in peripheral zone. **Ord.–Miss.**

C. robustum Hall (not Rominger) (**29**—20, 21). **M. Dev.** (Onondaga–Hamilton): Ont.; N. Y., Mich., Ohio (Silica), Ky. (Falls of Ohio).

DISPHYLLUM Fromentel 1861

(**Cyathophyllum caespitosum* Goldfuss). Rugose corals with touching or distant corallites; septa tend to dilate and become carinate; axial tabulae flat or gently curved, usually complete, often supplemented by inclined, periaxial tabulae; globose dissepiments, which may be arranged in a vertical series of horseshoes to form wall of tabularium. **Dev.** (N. America; Europe; Asia; Australia).

D. occidens Stumm (**29**—22, 23). **M. Dev.:** Nev. (Nevada).

GRYPOPHYLLUM Wedekind 1922

(**G. denckmanni*). Cyathophylloid corals characterized by great development of dissepimental structure; over 100 major septa, which reach nearly to axis; secondary septa not well developed. **Dev.**

G. giganteum Stumm (**29**—24). **M. Dev.:** Nev. (Nevada).

SYNAPTOPHYLLUM Simpson 1900

(**Diphyllum arundinaceum* Billings). Like *Eridophyllum*, but without the central wall, the septa extending across the tabulate area to near center; cylindrical; proliferations proceeding from all sides of corallites; distinguished by digitate septa and usually strong carinae. **Sil., Dev.**

S. multicaule (Hall) (**29**—25–28). Corallites 2 to 5 mm in diameter and same or greater distance apart, proliferations at irregular and infrequent intervals; calyx deep; septa about 24. **Niagaran:** Ont.; N. Y., Mich. **U. Monroan:** Ont.; Mich.

S. simcoense (Billings) (**30**—1–4). Corallites averaging 4 mm in diameter and distant about the same amount; septa 40 to 50. **M. Dev.** (Onondaga): Ont.; N. Y., Mich., Ohio (Columbus), and southwestern U. S. A.

***S. arundinaceum** (Billings) (**30**—5–7). Vesicular zone narrow; tabulae regular; septa not reaching center; diameter of corallites 6 to 10 mm. **M. Dev.** (Onondaga): Ont.; N. Y.

CYLINDROPHYLLUM Simpson 1900

(**C. elongatum*). Phaceloid rugose corals with marginal and nonparricidal budding; epitheca thin, annulated; calices deep; septa major and minor, major may reach axis; septal grooves distinct; carinae numerous; outer zone composed of strongly arched dissepiments, which tend to be arranged in vertical rows; inner zone occupied by complete and incomplete tabulae. **Dev.**

***C. elongatum** Simpson (**30**—8). **Onondaga:** N. Y.

C. panicum (Winchell) (**30**—9, 10). Corallum hemispherical, consisting of approximately parallel, cylindrical corallites; epitheca thin, concentrically wrinkled with well defined annulations; a single low indistinct septal ridge is present between each longer and shorter septum. **Traverse:** Mich.

C. hindshawi Ehlers and White (**30**—15). **Traverse:** Mich.

HEXAGONARIA Gürich 1896

(= PRISMATOPHYLLUM Simpson 1900; ACERVULARIA and CYATHOPHYLLUM of many earlier American authors)

(**Cyathophyllum hexagonum* Goldfuss). Corallum composed of prismatic corallites in contact and of essentially equal diameter for entire length; similar to *Heliophyllum* in internal structure. **Dev.** (widespread in U. S. A.; worldwide).

H. prisma (Lang and Smith) (= **Cyathophyllum rugosum** (Edwards and Haime)) (**30**—11, 12). Corallites relatively large, carinae few, and septa abundant; major septa continue to center of corallite instead of terminating at edge of central tabulate zone. **Columbus:** Ohio

H. anna (Whitfield) (**30**—19, 20). Differs from preceding by numerous carinae and by abrupt termination of septa before reaching center. **M. Dev.:** Ohio.

H. percarinata Sloss (**30**—16–18). This is the coral of the familiar "Petoskey stones" of northern Michigan, and has usually been identified as *Prismatophyllum davidsoni* (Edwards and Haime). **Traverse:** Mich.

H. parvula Stainbrook (**30**—13, 14). Corallites smaller and calices shallower than in most species. **U. Dev.:** Ia. (Cedar Valley).

TABULOPHYLLUM

C. L. Fenton and M. A. Fenton 1924

(**T. rectum*). Cyathophylloid corals with peripheral dissepimentarium and tabulae which are occasionally

PLATE 33

[Figures are x1 unless otherwise indicated.]

1–13. Cystiphyllum spp. 1–5, C. niagarense. Two weathered specimens [Mich G S 3]; enlarged portions of surface and complete corallum [Pal N Y 2]. **6, 7. C. sulcatum** [Pal N Y 6]. Top and side views (x0.8). **8–10. C. conifollis.** Complete specimen [Pal N Y, Dev Corals]; enlarged sections (x2) [Carnegie Mus, An 27]. **11–13. C. americanum.** Sections showing internal structure (x2) [Carnegie Mus, An 27]; a large weathered specimen [NAIF]. **14–17. Mesophyllum spp. 14, 15. M. lonense** [JP 11]. **16, 17. M. vesiculosum** [JP 12]. **18. Cystiphyllum aggregatum** [CGS, Contr Can Pal 4]. **19–21. Chonophyllum magnificum** [Mich G S 3]. Side and calicular views and a fragment of the wall.

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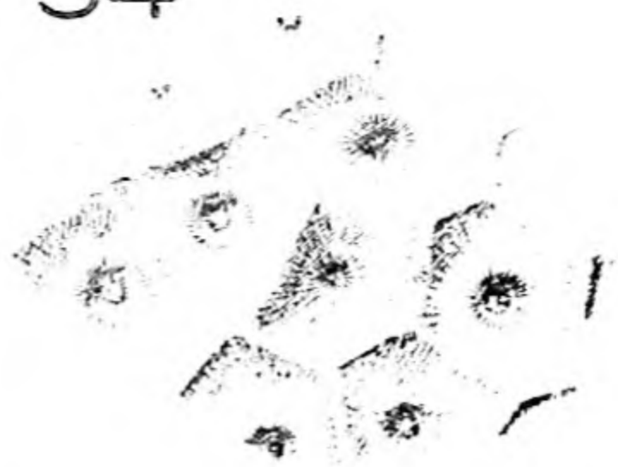

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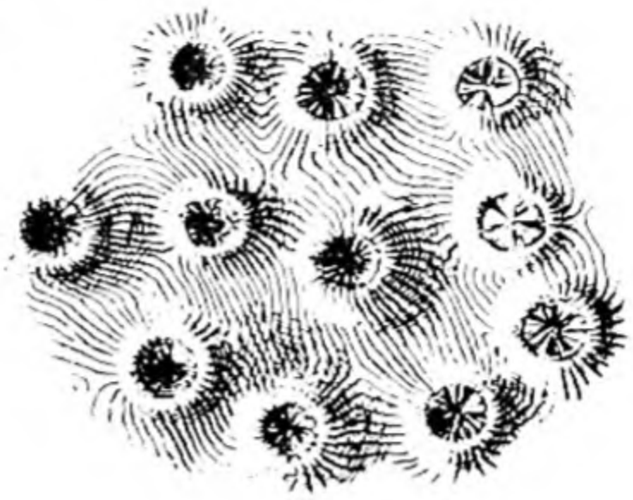

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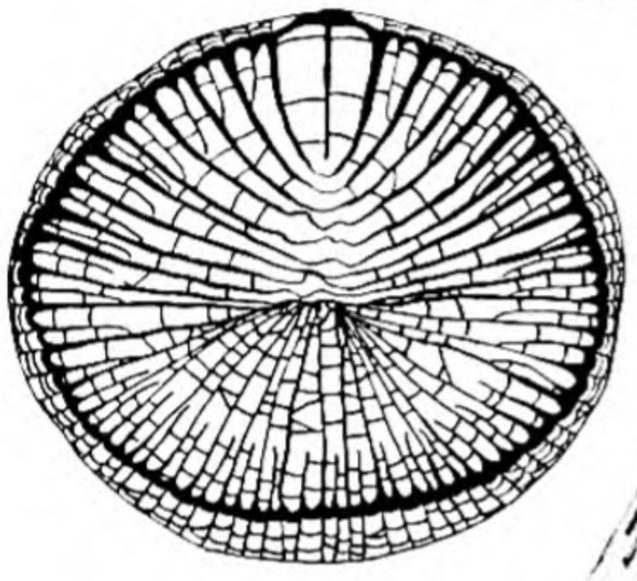

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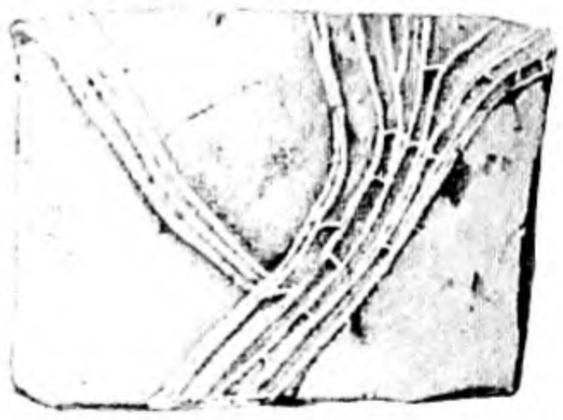

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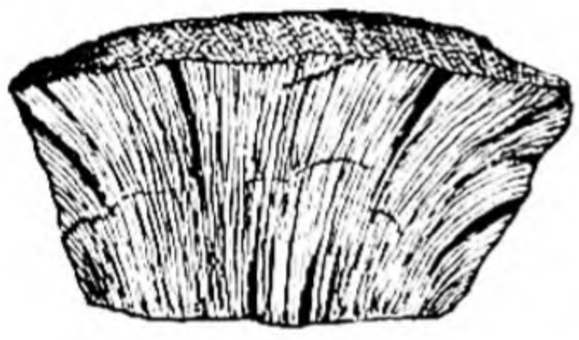

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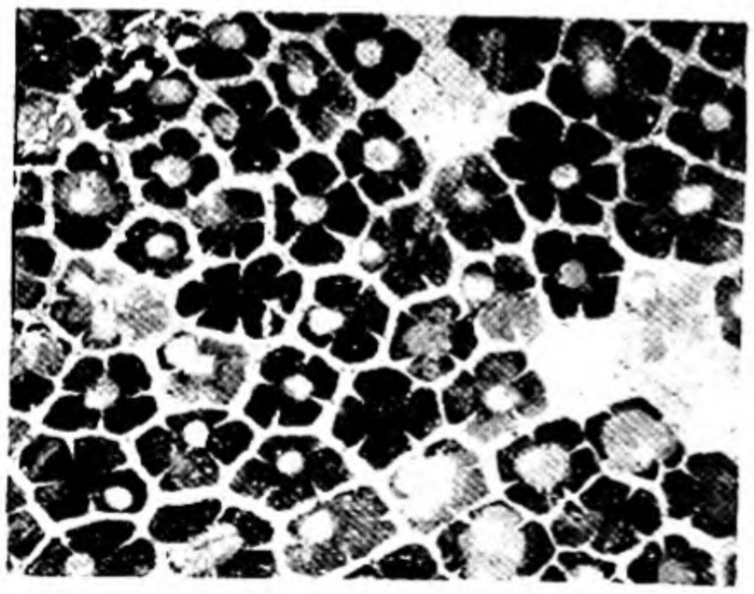

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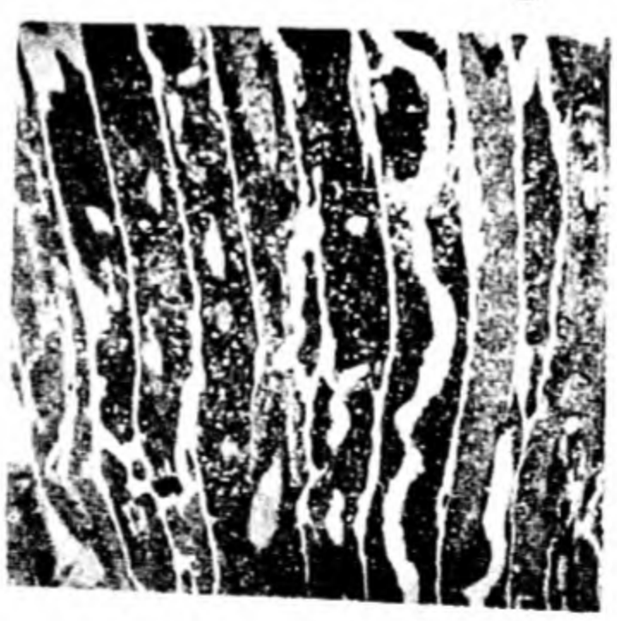

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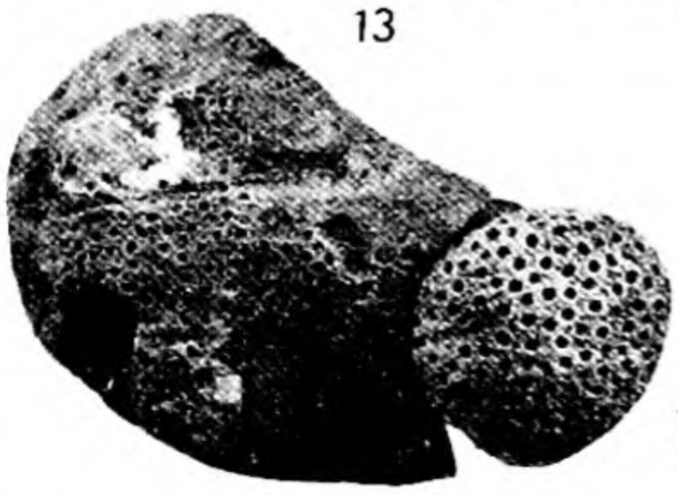

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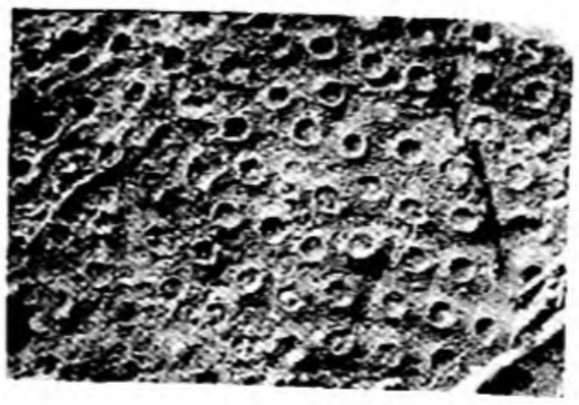

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complete but usually are broken up into short tabellae. **Dev.** (Canada; Mich., Ia., Nev.)

***T. rectum** F and F (**31**—1–4). **U. Dev.:** Ia.

BLOTHROPHYLLUM Billings 1859

(**B. decorticatum*). Corallum cylindrical, consisting of a series of invaginated cups with well developed tabulae and generally with a marked fossula; projecting margins of the older cups cystose and covered by epitheca; epitheca commonly worn away. **Sil., Dev.**

***B. decorticatum** Billings (**31**—5, 6). Large, with margins of old calices strongly projecting, generally denuded of epitheca; in calyx a deep siphono-fossula and smooth central space are characteristic. **M. Dev.** (**Onondaga**): Ont.; Mich., Ky. (Falls of Ohio).

PALAEOSMILIA Edwards and Haime 1848

(**P. murchisoni*). Corallum solitary; dissepiments densely arranged in central area; major septa reach center where they are crowded and sometimes twisted; septa may unite to produce a structure resembling a streptocolumella. **L. Carb.–L. Perm.** (worldwide distribution).

P. schucherti Heritsch (**31**—12–14). **L. Perm.:** Tex. (Saddle Creek).

HELIOPHYLLUM Dana 1846

(**H. halli* Edwards and Haime). Like *Cyathophyllum*, but with septa thickened on their sides by opposite vertical carinae, which are few and weak in young or primitive species but numerous and strong in others. **Dev.**

***H. halli** E and H (**31**—8–11). Broadly turbinate at base or in young specimens, becoming cylindrical in old individuals, frequently with irregular constrictions showing rejuvenescence; epitheca strongly wrinkled. **Onondaga:** Ohio (Columbus). **Hamilton:** Ont.; N. Y., Mich., Ky., Wis., Ia. (Numerous varieties of this "form species" have been reported from the Hamilton of New York by Wells (1937).)

H. tenuiseptatum (Billings). Generally small, more or less cylindrical, with numerous fine and thin, strongly carinated septa. **Hamilton:** Ont.; N. Y., Mich.

PTYCHOPHYLLUM Edwards and Haime 1850

(**P. stokesi*). Similar to *Chonophyllum*, but with the septa twisted into a pseudocolumella at the center; septa thin, breaking up peripherally; a wide marginal zone of dissepiments. **Sil., Dev.**

***P. stokesi** E and H (**31**—15-17; **32**—19, 20). Conical, with a deep, spreading calyx furnished with low, broad septa and a large pseudocolumella; epitheca with rootlike processes. **Niagaran:** Que., Ont.; Mich. (Manistique), Ind., Ky., Wis., Ia.

PACHYPHYLLUM[1] Edwards and Haime 1850

(**P. bouchardi*). Corallum compound, composed of confluent corallites not bounded by polygonal walls; each corallite with a central conical elevation, at the top of which is a craterlike pit; septa extending over outside of cone as low costae; the longer septa extend to within short distance of center; carinae wanting; margins often with vesicular dissepimental zone. **Dev.**

P. woodmani (White) (**32**—1, 2). Growing in convex or hemispherical masses 25 to 150 mm (1 to 6 in.) in diameter; crater rims strongly elevated, sometimes more than 3 mm; crater deep and variable in character. **U. Dev.:** Ia., Nev. (Devils Gate), Ariz. (Martin).

BILLINGSASTRAEA Grabau 1917

(**Phillipsastraea verneuili* Edwards and Haime). Corallum heliophylloid; individual corallites not bounded by walls, but septa are confluent or abut against one another at their peripheral extremities; septa heavily carinate; interseptal spaces with dissepiments; tabulae confined to a narrow axial region, and are usually broken up into short horizontal tabellae by axial portions of major septa. **Dev.**

***B. verneuili** (E and H) (**31**—7). **Onondaga, Hamilton:** Ont.; Mich.

B. billingsi (Calvin). **Hamilton:** Mich.; Ia., Nev. (var. **nevadensis** Stumm (**32**—10)).

FAVISTELLA (Dana 1846) Hall 1847

(= COLUMNARIA of most American authors [See Hill 1939])

(**F. stellata*). Corallum massive, hemispherical or globose, composed of polygonal tubes which increase

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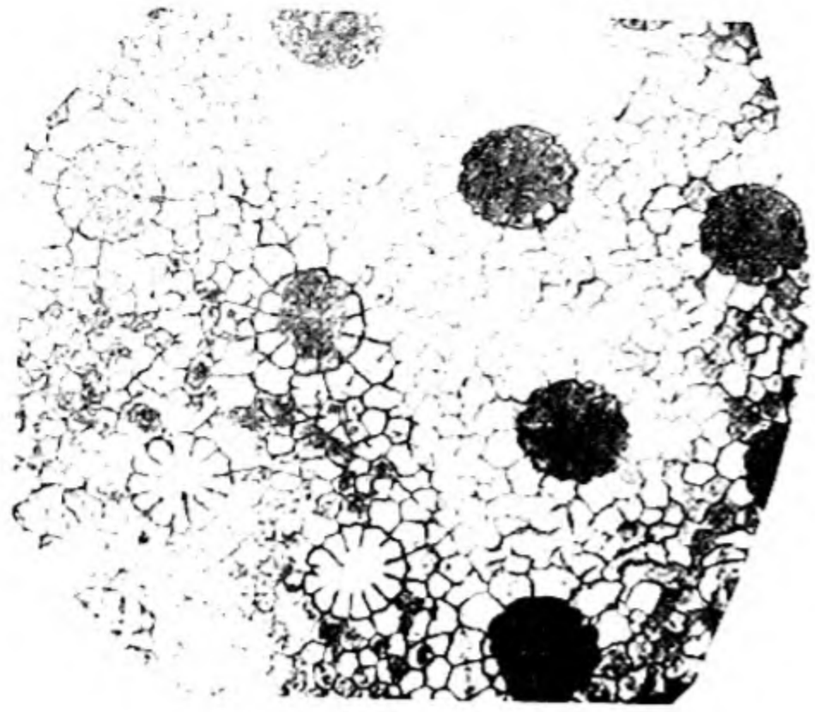
[1] Lang, Smith, and Thomas (1940, 92) consider *Pachyphyllum* synonymous with *Phillipsastraea*, and are followed in this view by Stumm (1940, 64); Ehlers (personal communication), however, dissents from this view. For the present, we prefer to follow Ehlers.

PLATE 34

[Figures are x1 unless otherwise indicated.]

1–5. Arachnophyllum spp. 1. A. striatum [Mich G S 3; photograph furnished by G. M. Ehlers]. **2–4. A. pentagonum.** Septal ridges (x4) showing double rows of pore openings and diagram of calicular surface [CGS, Contr Can Pal 4]; a group of calices [Mich G S 3]. **5. A. mamillare** [CGS, Contr Can Pal 4]. Upper surface. **6–8. Aulacophyllum spp. 6. A. bilaterale** [JP 13]. Diagrammatic cross section (x1.3). **7, 8. A. sulcatum** [Ind G S 12]. Alar and calicular views. **9–16. Tetradium spp. 9–11. T. cellulosum.** Cross section (x7) [R Soc Can, Tr 29]; two specimens showing natural sections [Pal N Y 1]. **12–16. T. fibratum.** A diagrammatic corallum [NAIF]; cross section (x7) and longitudinal section (x5.5) showing details of structure [R Soc Can, Tr 29]; diagrammatic cross section of several corallites (x6) [CGS, Contr Can Pal 4]; and view of calicular surface (x6) [Tenn G S, B 38]. **17, 18. Heliolites spp. 17. H. elegans** [Mich G S 3]. Two coralla. **8. H. megastoma** [Ky G S, Ky Fos Corals]. A portion of the surface.



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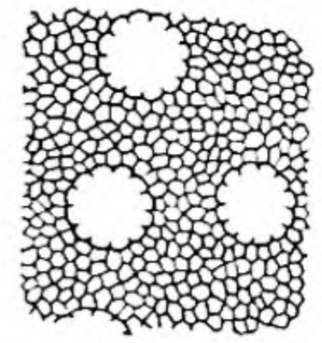

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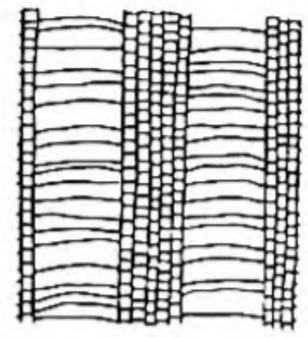

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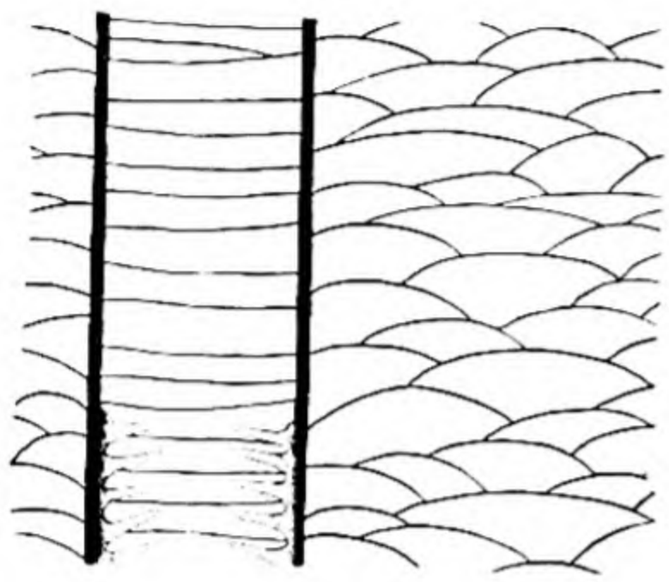

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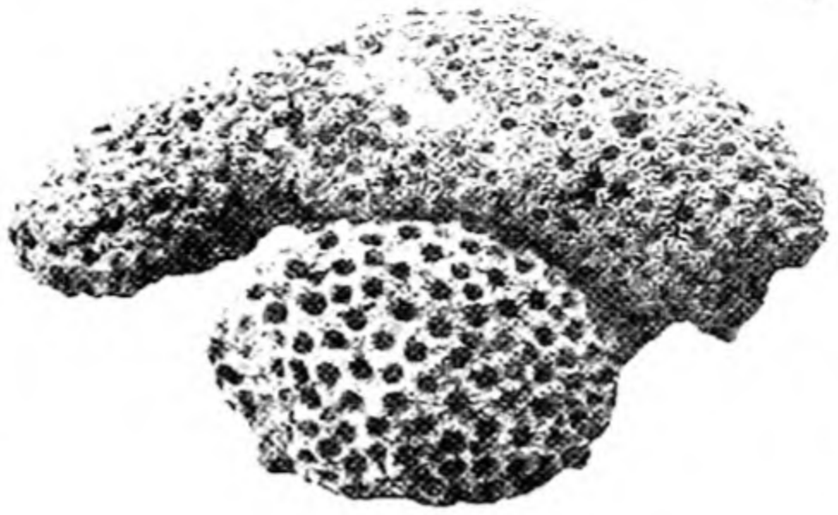

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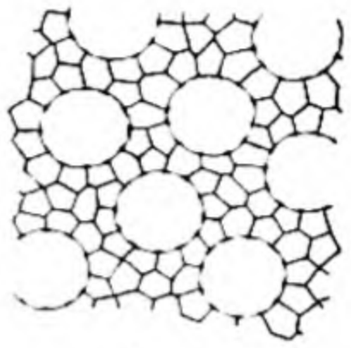

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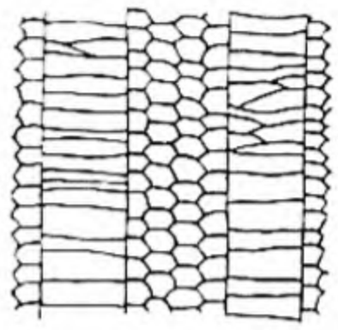

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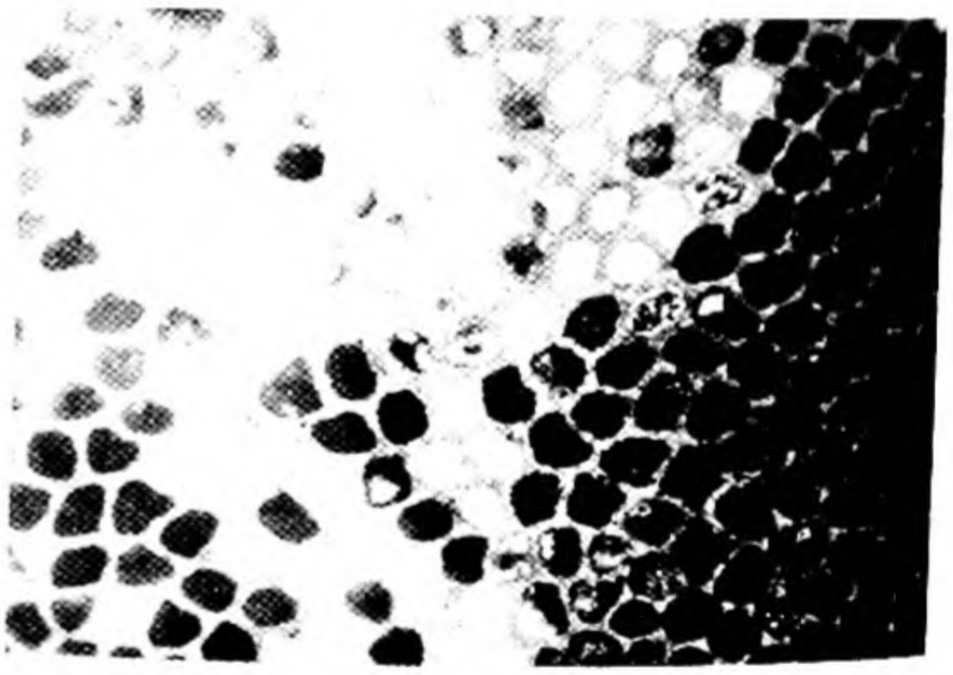

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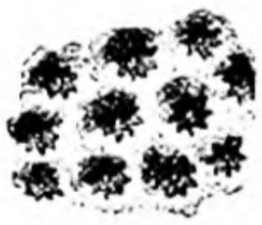

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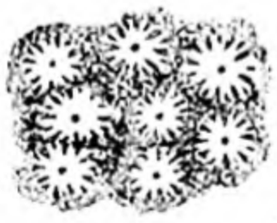

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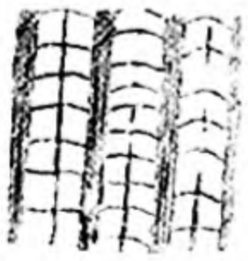

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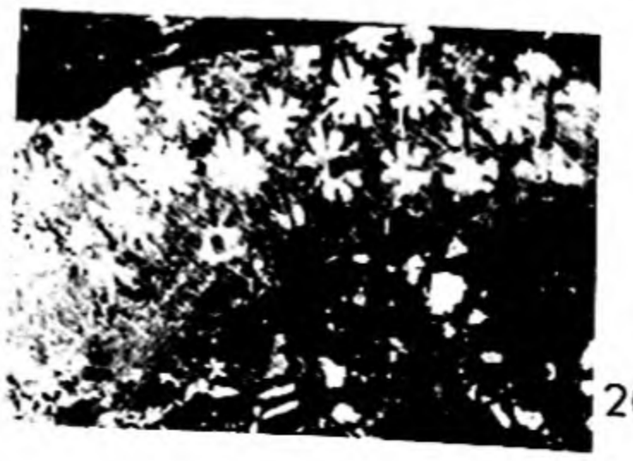

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by interstitial or lateral budding; corallites tabulated and strongly septate; septa 12, generally reach a half to a third the distance from margin of corallite to center. **Ord.–Dev.**

***F. stellata** Hall (**32**—6, 7). (Commonly identified as *Columnaria alveolata* Goldfuss). **U. Ord.** (common throughout N. America).

F. halli. (Nicholson) (**32**—3, 8, 9). Corallites with 20 to 40 longitudinal ridges (septa); tabulae flat, close, and smooth in the centers; corallites variable in diameter, 2 to 5 mm, with occasional large ones 10 mm in diameter among the smaller ones. **M. Ord.** (Black River-Trenton): Que.; N. Y., Pa., Tenn., Mich., Ind., Ill., Minn., Ia.

F. alveolata (Goldfuss) (**32**—4, 5). Corallites 3 to 6 mm in diameter; septa 20 to 30, alternately larger and smaller, with former extending to center. **M.** and **U. Ord.:** Common throughout eastern and central N. America (Stones River–Richmond), and in Richmond of New Mexico.

DIPLOPHYLLUM[1] Hall 1851

(**D. caespitosum*). Corallum similar to *Synaptophyllum*, but without the connecting epithecal expansions; tabulate area large. **Sil., Dev.**

***D. caespitosum** Hall (**32**—11, 12). Slender cylindrical corallites with broad central tabulate area and narrow peripheral zone; septa thin, reaching center. **Sil. U. Medinan:** Anticosti; Ont. **Niagaran:** Ont.; N. Y., Wis. (probably more restricted stratigraphically than this record indicates).

ACROPHYLLUM Thomson and Nicholson 1876

(**Clisiophyllum oneidaense* Billings). Corallum simple, with tabulae elevated tentlike in center of calyx; septa running out on them and twisted at center. **Dev.**

***A. oneidaense** (Billings) (**32**—13). Corallum turbinate or cylindrical, with periodic constrictions; sides of calyx nearly vertical, bottom of cup nearly half the diameter of the corallum; fossula strong, extending from base of elevation to calyx margin. **Onondaga:** James Bay, Ont.; Mich., Ky. (Falls of Ohio).

ENTELOPHYLLUM Wedekind 1927

(= XYLODES Lang and Smith 1927)

(**Madreporites articulatus* Wahlenberg). Corallum of cylindrical corallites which are brought into contact by lateral outgrowths as septa thin, the longer reaching or nearly reaching center; carinae feeble to strong, arranged alternately at angles of zigzag septa; tabulae horizontally disposed; dissepiments numerous, small, globose. **Sil.**

E. rugosum (Smith) (= **Eridophyllum rugosum** Edwards and Haime of authors) (32—14–16). Corallites slender; each corallite expanding at more or less regular intervals from one side; expansions of dissepimental and epithecal material rise obliquely and end in 2 to 3 spiniform processes connecting the corallites; carinae apparently absent. **Niagaran:** Ont.; Ind., Ky.

CALCEOLA Lamarck 1799

(**Anomia sandalinum* Linnaeus). Corallum simple with one side flattened and with a deep calyx opening obliquely and furnished with an operculum; septa in form of low ridges; structure densely cystose. **Sil.–Penn.**

C. (Rhizophyllum) tennesseensis Rominger (**32**—17, 18). Strongly curved, with a high arched operculum and vesiculose interior. **M. Sil.:** Tenn. (Brownsport).

CYSTIPHYLLUM Lonsdale 1839

(= CONOPHYLLUM Hall 1851)

(**C. siluriense*). Coralla simple or compound, varying from depressed turbinate to cylindrical or irregular form; entire interior of corallum filled with vesiculose material with a conical arrangement of vesicles; calyx without septa or with only faint ridges as in *Chonophyllum*, from which genus it was probably derived; strongly wrinkled epitheca present. **Sil., Dev.**

C. niagarense (Hall) (**33**—1–5). Cylindrical in the upper portion with frequent constrictions; septa subdued, spiniform, with notched margins, extending to center of deep calyx. **Niagaran:** Anticosti; N. Y., Mich., Ky., Wis.

C.? sulcatum (Billings) (**33**—6, 7). Short, conical and curved corallum, with a deep cardinal fossula; septa represented by coarse plications of the calyx floor. **M. Dev.** (Onondaga): Ont.; N. Y., Mich., Ky.

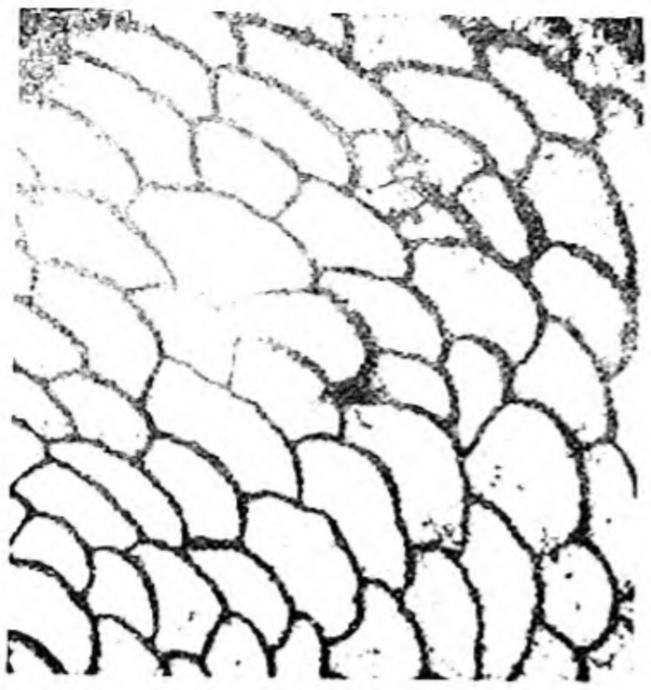
C. "americanum" Edwards and Haime (= **C. vesiculosum** and probably several other species of American authors) (**33**—11–13). Large, cylindrical, frequently constricted, covered with thin but strongly wrinkled epitheca; calyx with faint indication of septa; vesicular material coarsest near center. **Onondaga, Hamilton:** Ont. to Md., westward to Ky. (Falls of Ohio) and Ia.

[1] May be a genomorph of ACERVULARIA as Smith and Lang (*An Mag N H* (10) 8: 86, 1931) suggest.

PLATE 35

[Figures are x1 and after Lambe [CGS, Contr Can Pal 4] unless otherwise indicated.]

1–5. Hellolites interstinctus. 1, 3: Cross and longitudinal sections (x5) [JP 13]; 2: A typical corallum [British Fos Corals 1854]; 4, 5: Diagrammatic sections (x5). **6–8. Plasmopora follis.** 6: Two typical coralla [Mich G S 3]; 7, 8: Diagrammatic sections (x5). **9–11. Lyellia americana** [Ind G S 11]. Diagrammatic sections (x5); part of a weathered corallum. **12–15. Chaetetes milleporaceus.** 12: A typical corallum [Mo G S 4]; 13–15: Cross and longitudinal sections (x9) and second longitudinal section (x12) [original by R. R. Shrock]. **16–20. Billingsaria parva.** 16–18: Surface, cross, and longitudinal sections (all x5); 19, 20: Longitudinal (x4.7) and cross (x6.6) sections [R Soc Can, Tr 30].



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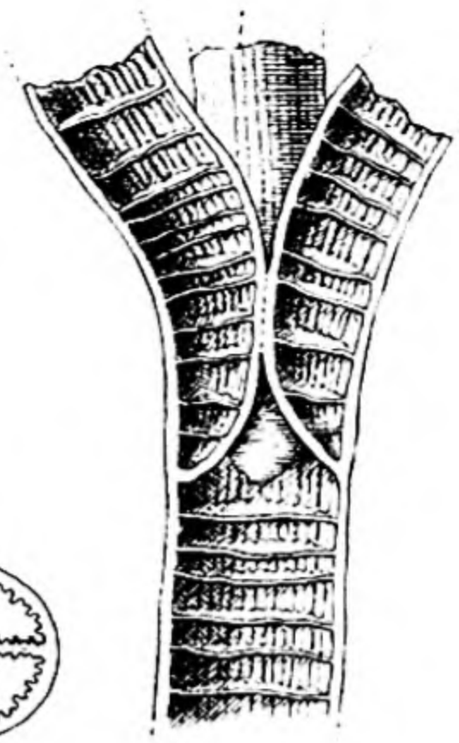

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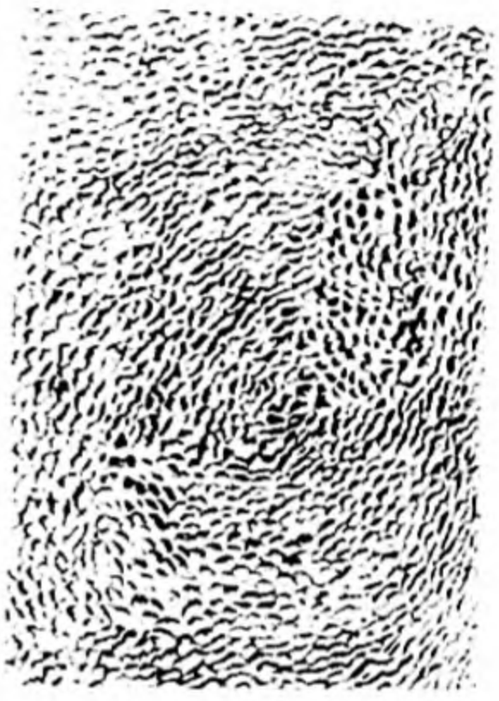

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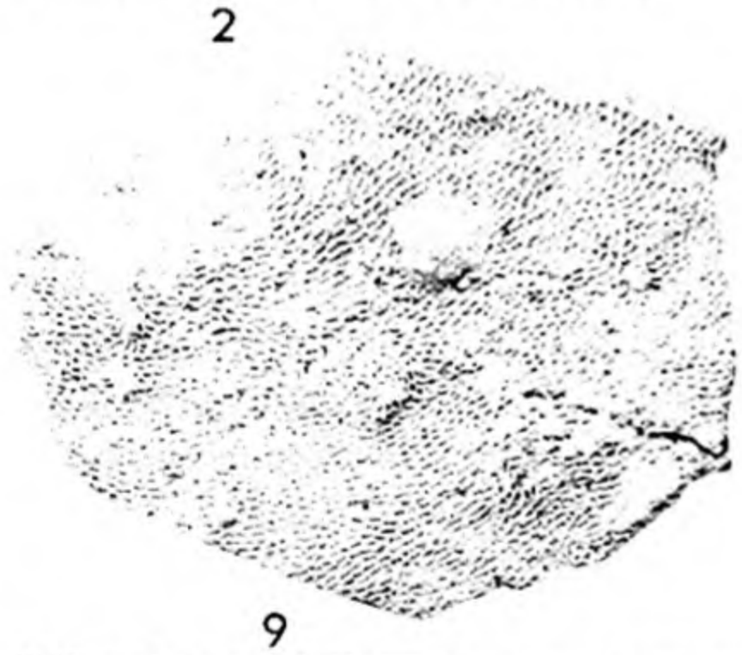

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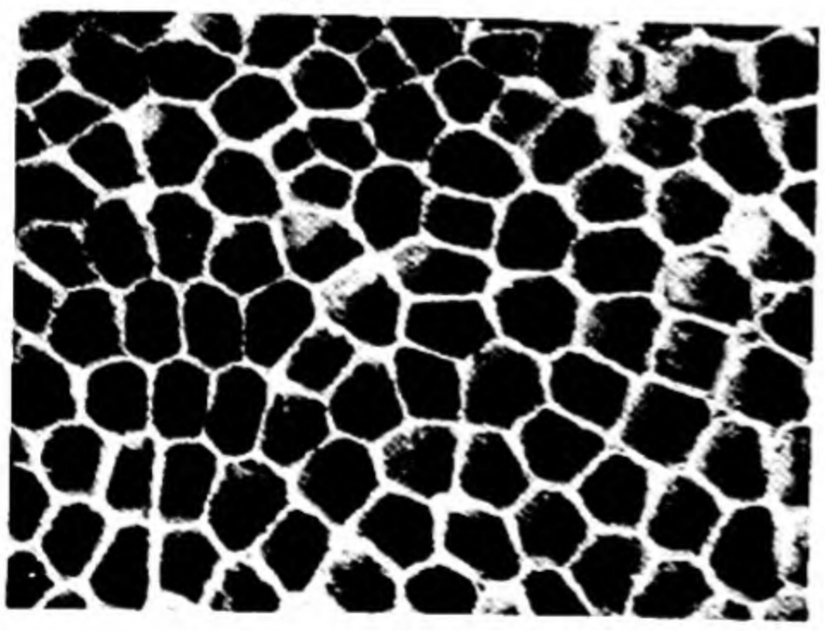

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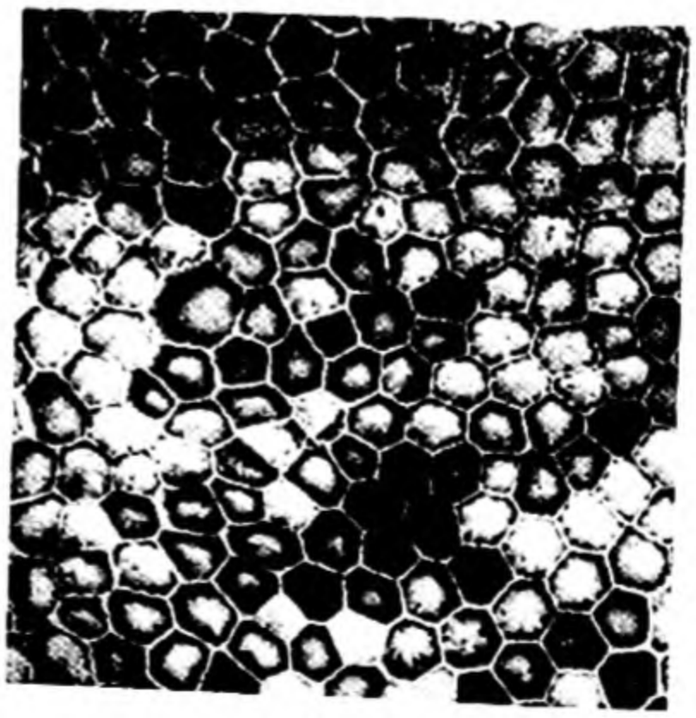

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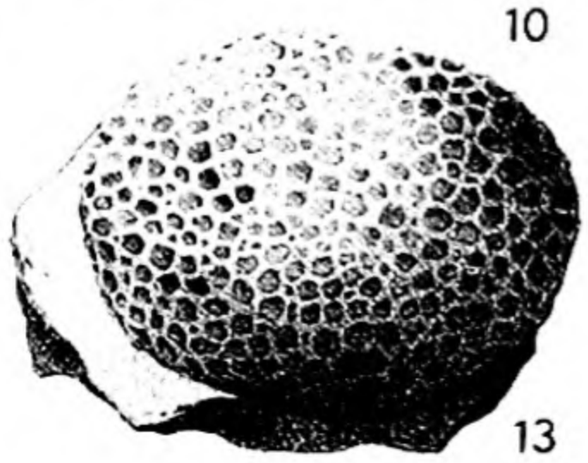

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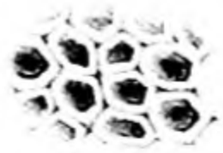

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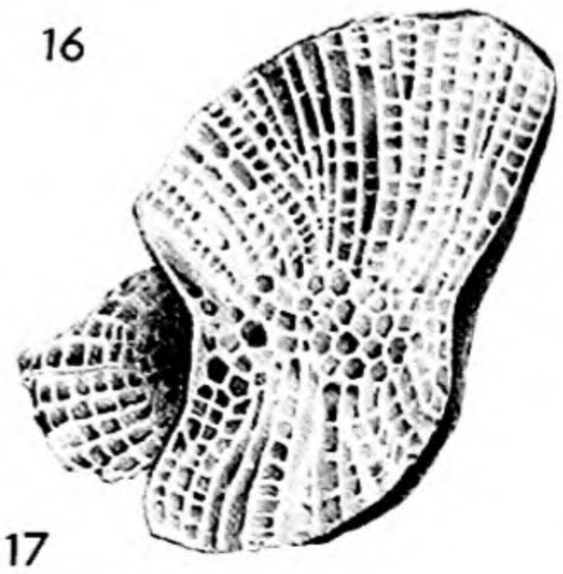

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C. conifollis Hall (**33**—8–10). Slender, cylindrical, with periodic constrictions; cysts arranged radially at base of calyx. **Hamilton:** Ont.; N. Y., Mich.

C. aggregatum Billings (**33**—18). Compound corallum composed of closely crowded corallites attached to one another by epithecal proliferations. **Onondaga:** Ont.; **Hamilton:** Mich. (**C. aggregatum caespitosum** Schlüter has looser manner of growth than is typical, so that corallites may be separated by intervals equal to their diameter; it occurs with the above species and also in the **M. Dev.** of Eifel.)

CHONOPHYLLUM Edwards and Haime 1850

(**Cyathophyllum perfoliatum* Goldfuss). Generally top-shaped or subcylindrical coralla composed of invaginated funnels; calyx large with numerous uniform septa; composed of superposed layers of sclerenchyma; margins of old funnels not projecting. **Sil., Dev.**

C. magnificum (Billings) (**33**—19–21). Large, top-shaped, with a spreading basin-shaped calyx; septa thickening outward. **Onondaga:** Mich., Ind., Ky. (Falls of Ohio).

MESOPHYLLUM Schlüter 1889

(**M. defectum* = *Cyathophyllum vesiculosum* Goldfuss = *Cystiphyllum vesiculosum* of authors). Devonian corals having same structure as *Cystiphyllum* Lonsdale, but which are not related to the genotype of that genus. **Dev.**

***M. vesiculosum** (Goldfuss) (**33**—16, 17). **M. Dev.** (Hamilton): Eastern N. America. Nev. (Nevada).

M. lonense Stumm (**33**—14, 15). **M. Dev.:** Nev. (Nevada).

ARACHNOPHYLLUM Dana 1846

(= STROMBODES of earlier American authors)

(**Acervularia baltica* Lonsdale (non Schweigger) = *Strombodes murchisoni* Edwards and Haime). Corallum low, spreading, consisting largely of dissepiments and secondary septal tissue, and having very small intrathecal areas; corallites large, polygonal; calices shallow; septa reaching or nearly reaching axis, are largely degenerate and are normal only at and within theca; outside they appear as spinose crests on successive dissepimental floors; crests increase in number peripherally and, developing transverse tissue, tend to form a trabecular meshwork. **Sil.** (widely distributed throughout N. America).

A. pentagonum (Goldfuss) (**34**—2–4). Calices shallow, 10 to 15 mm in diameter; center with a styliform columella; septa sharp at the pit, becoming low rounded ridges at margins. **Niagaran:** Que., Ont.; Mich., Ind., Wis., Ky., Tenn.

A. striatum (Orbigny) (34—1). Much larger than preceding, with calices as much as 40 mm in diameter; elevations around central pit pronounced. Occurs with preceding.

A. mamillare (Owen) (**34**—5). Margins of calices depressed, center strongly elevated with pronounced craterlike pit at top with diameter of 4 to 5 mm; distances between centers of pits of adjoining corallites 10 to 20 mm. Occurs with preceding two species.

AULACOPHYLLUM Edwards and Haime 1850 (**Caninia sulcata* Orbigny). Like *Zaphrentis*, but with septa on each side of fossula converging toward it. **Sil., Dev.**

***A. sulcatum** (Orbigny) (**34**—7, 8). Regularly curved, with shallow, oblique calyx; most of septa converge to either the cardinal or two alar septa. **Onondaga:** Mich., Ohio (Columbus), Ky. (Falls of Ohio), Ia.

A. bilaterale Sloss (**34**—6). **Hamilton:** Mich.

Subclass Schizocoralla

Coralla simple, branching or massive; corallites long, slender, with imperforate walls and numerous complete, horizontal or slightly arching tabulae; walls of most corallites completely amalgamated; corallites provided with lamellar, vertical plates arranged around circumference of corallite and so resembling septa of the **Zoantharia;** main function of these plates is to provide asexual reproduction through simple fission of each corallite into two, three, or four corallites; columella present in some genera. **Ord.–Mesozoic.**

TETRADIUM Dana 1841, emend Okulitch 1935 (**T. fibratum* Safford). Coralla massive, branching, halysitoid, fasciculate, or a single tube; corallites are long slender tubes closely contiguous and with quadrangular to hexagonal cross-section; septa four, one in middle of each wall, usually not quite reaching center; secondary septa present in some forms, may number up to eight; walls without mural pores; tabulae and columella present or absent; corallites increase by fission. **Ord.**

T. cellulosum (Hall) (**34**—9–11). Branches consisting of several long, slender corallites with rhombic section, appearing quadrilobate from strong de-

PLATE 36

[Figures are x1 unless otherwise indicated.]

1, 2. Paleoalveolites paquettensis [R Soc Can, Tr 32]. Cross and longitudinal sections (x7). **3–5. Fletcheria guelphensis.** Part of a typically preserved corallum [CGS, M 111]; two diagrammatic sections (x2) [CGS, Contr Can Pal 4]. **6–9. Alveolites spp. 6–8. A. goldfussi** [Pal N Y, Dev Corals]. Complete corallum and portions of surface enlarged. **9. A. undosus** [Ky G S, Ky Fos Corals]. Portion of surface. **10–17. Favosites spp. 10–12. F. favosus.** Two calicular views of a corallum with large corallites [Mich G S 3]; a longitudinal section enlarged somewhat [Ind G S 12]. **13–17. F. niagarensis** [Pal N Y 2]. A small spheroidal corallum: a portion of surface somewhat enlarged; and three sections showing internal structure.

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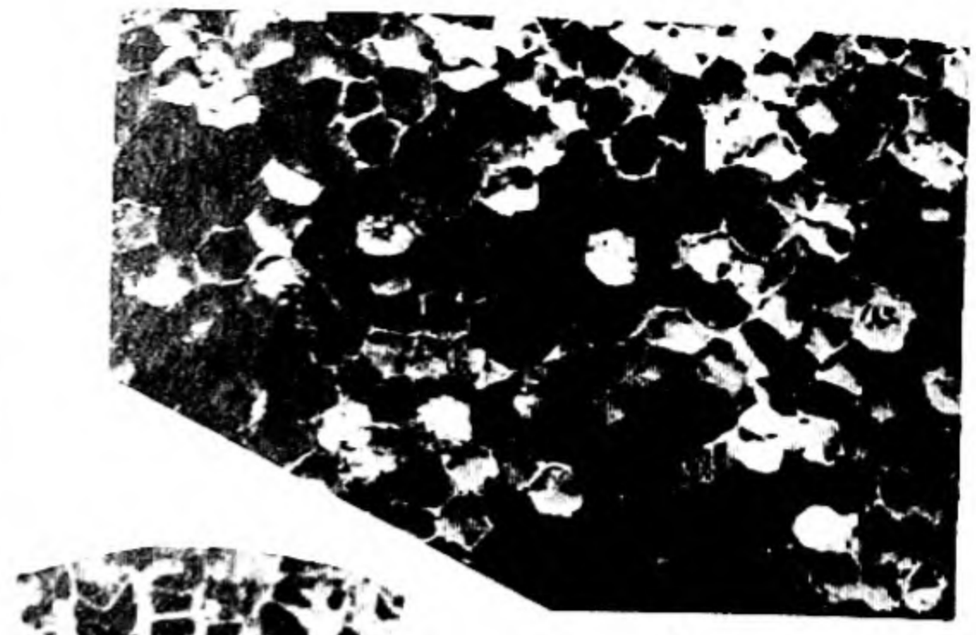

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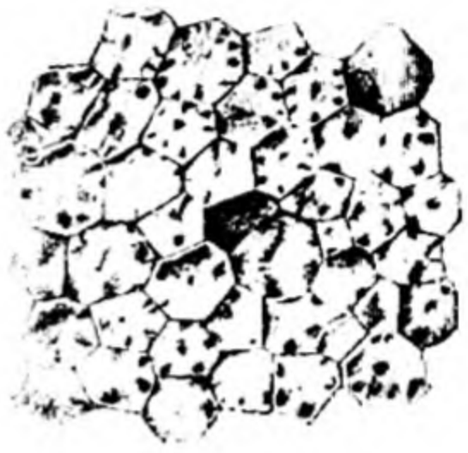

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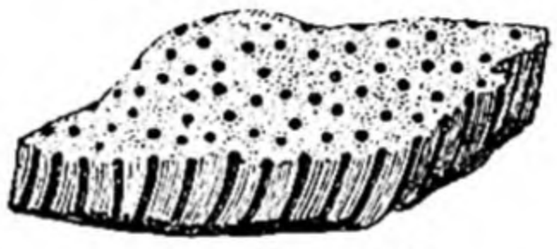

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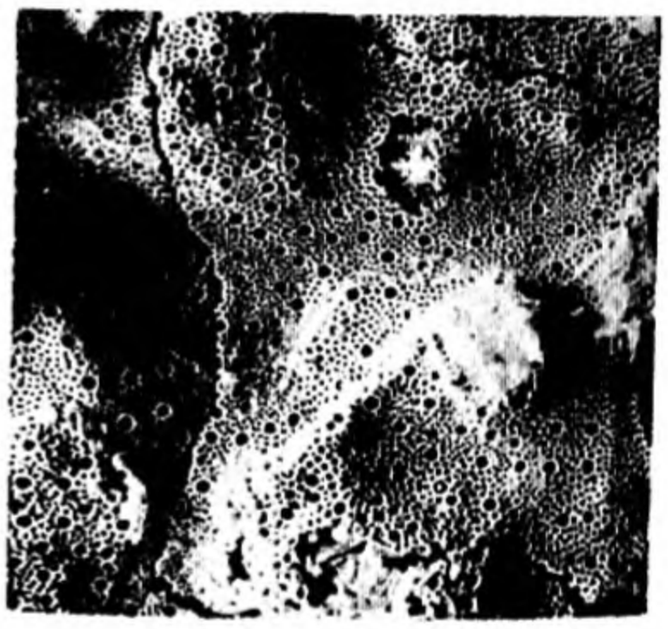

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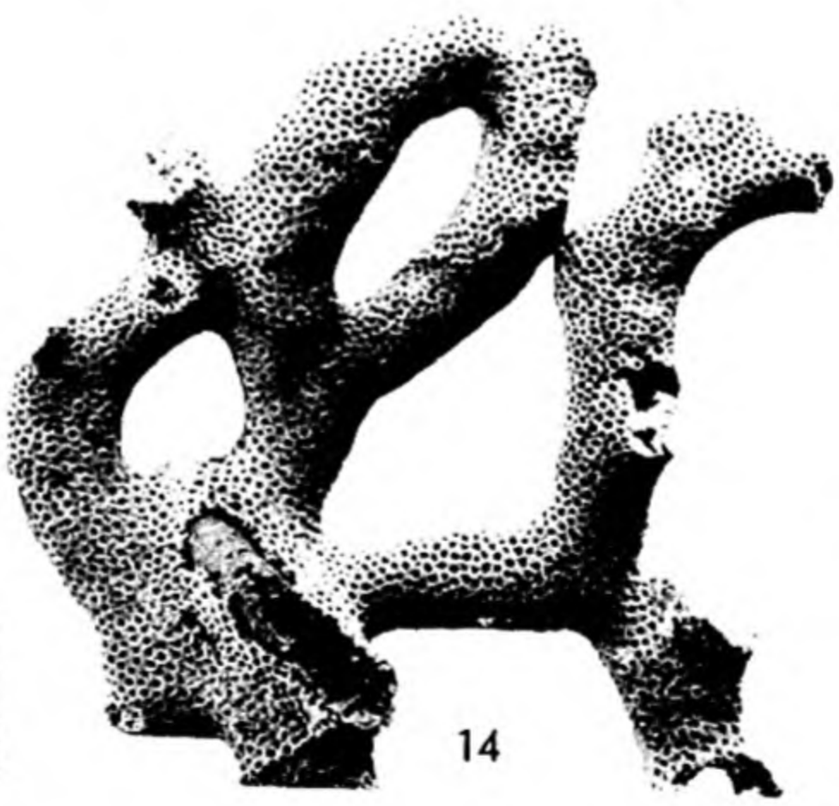

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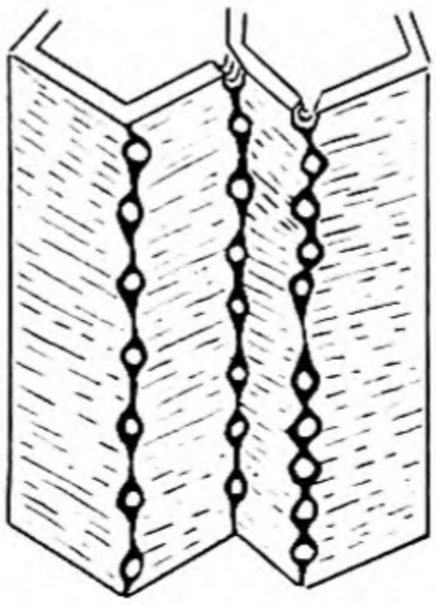

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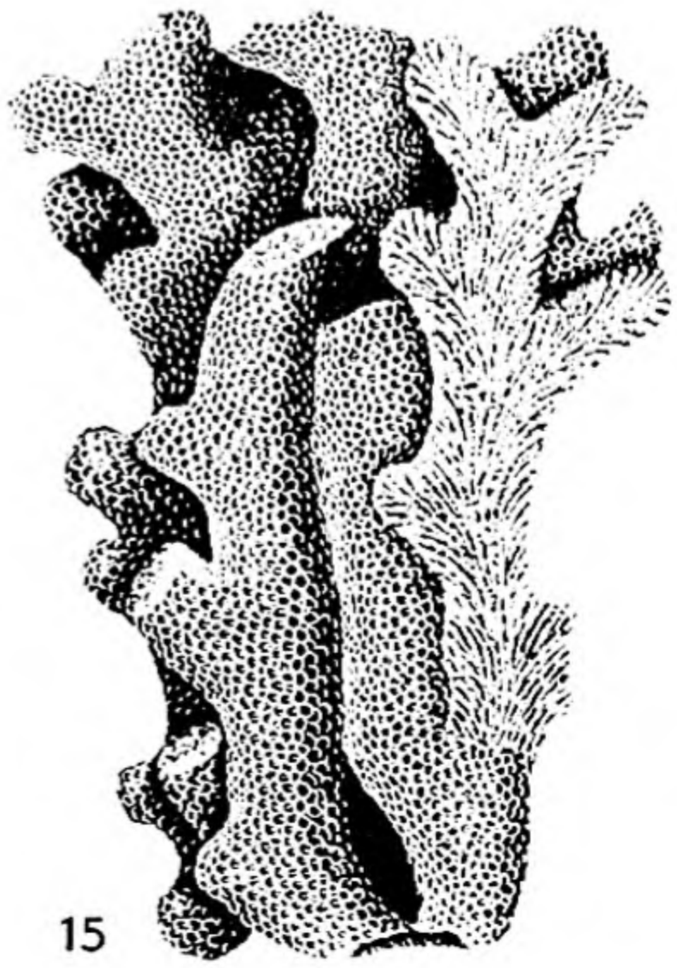

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velopment of four primary symmetrically placed septa. **Lowville, Black River:** Que to Ala., Ind., Tenn.; **Trenton:** Northeastern N. America.

***T. fibratum** Safford (**34**—12–16). Septa nearly reaching center; diameter of corallites about 1 mm. **Black River:** Que., Ont. **Trenton–Maysville:** Ont.; Va., Ky., Tenn. **Richmond:** Ont.; Ohio, Ind., Ky., Tenn.

T. syringoporoides Ulrich. Differs from *T. cellulosum* in slower rate of septal growth, which causes retardation of fission and produces long, slender coralla; septa thicker and only four; corallum commonly splits after four-celled stage is reached; adult coralla rarely have over four corallites to a bundle. **Stones River:** Md., Pa., Va., Tenn. **Pamelia:** Ont.; N. Y.

HELIOLITES Dana 1848

(**Astraea porosa* Goldfuss = *Héliolithe pyriforme* . . . Guettard). Corallum compound, varying from spheroidal to flabellate, with large cylindrical macrocorallites furnished with 12 infoldings of the wall, or pseudosepta, and numerous prismatic microcorallites investing the larger ones; tabulae in both types of corallites, but more numerous in smaller; no mural pores; basal peritheca present. **Ord.–Dev.**

H. megastoma McCoy (**34**—18). Convex coralla with macrocorallites about 2 mm in diameter and distant somewhat less; 12 very short pseudosepta; form subglobular. **Niagaran:** Arctic America; Ont.: N. Y., Mich., Wis., Ia., N. Mex.; Great Britain.

H. interstinctus (Linnaeus) (**35**—1–5). Discoid or in leaflike expansions with a basal peritheca; macrocorallites slightly larger than in *H. megastoma* and somewhat more distant; pseudosepta reaching nearly to center in well preserved specimens; microcorallites polygonal. **Niagaran:** Newf.; Ont. (Cataract); Mich. to Tenn., Ind.

H. elegans Hall (**34**—17). Coralla hemispheroidal, with macrocorallites a little over 0.5 mm in diameter, and pseudosepta in form of oblique spines reaching halfway to center; microcorallites crowded, minute. **Niagaran:** Ont.; N. Y., Mich., Ind., Ky.

PLASMOPORA Edwards and Haime 1849

(**Porites petalliformis* Lonsdale). Differs from *Heliolites* chiefly in having no distinct walls or tabulae (only vesicular material) in the microcorallites. **Sil. Dev.**

P. follis E and H (**35**—6–8). Microcorallites 1 to 1.5 mm in diameter with circular, crenulated apertures, and separated by an equal width; growth in pyriform or subcylindrical club-shaped masses, with a rudimentary peritheca at conical base. (Probably more than one species has been given this name.) **Niagaran:** Que., Ont.; Mich. to Tenn.

LYELLIA Edwards and Haime 1851

(? = PROPORA Edwards and Haime 1849)

(**L. americana*). Corallum consisting of numerous cylindrical corallites growing parallel and united by vesicular coenenchyma; septa 12; tabulae short, irregular. **Sil.**

***L. americana** E and H (**35**—9–11). Corallites 1.5 to 2 mm in diameter, separated by two corallite diameters or less; septa comparatively short; coenenchyma of fine cysts. **Niagaran:** Newf.; Anticosti; Que., Ont.; Mich., Ind., Ky., Tenn.

CHAETETES Fischer in Eichwald 1829

(**C. cylindraceus Fischer*). Massive, composed of long, narrow, prismatic, thin-walled corallites; tabulae complete, remote or crowded; septa absent but pseudosepta common; probably no mural pores. **Ord.–Jura.**

C. milleporaceus Edwards and Haime (possibly = *C. radians* Fischer) (**35**—12–15). Corallum massive, as much as 30 cm (1 ft) across; corallites with one diameter usually longer than other, average diameter about 0.3 mm. **Penn.:** Widespread throughout N. America. It is very likely that several distinct corals have been referred to this "form species."

FLETCHERIA Edwards and Haime 1851

(= PYCNOSTYLUS Whiteaves 1884)

(**F. tubifera*). Corallum of cylindrical tubes increasing by calicular budding of 3 to 4 branches at distant intervals; septa in form of short vertical ridges; tabulae well developed, horizontal. **Sil.**

F. guelphensis (Whiteaves) (**36**—3–5). [Lang, Smith and Thomas (1940, 112) state that *P. guelphensis*, the genotype of *Pycnostylus*, "is at least congeneric with the genotype of *Fletcheria*."] Long slender corallites 3 to 7 mm in diameter; epitheca with transverse constrictions and reelevations at irregular intervals, but without longitudinal ribs. **Niagaran:** Ekwan River, Hudson Bay, Ont. (Guelph); Ind. (Huntington), Wis. (Racine); Man.

Subclass Alcyonaria (= Octocoralla Haeckel)

Corallum usually calcareous, consisting of roughened spicules; budding takes place on tubular outgrowths of the zooids; cavities of zooids not in direct

PLATE 37

[Figures are x1 unless otherwise indicated.]

1–15. Favosites spp. 1, 2. F. helderbergiae [Pal N Y 6]. Top and side views. **3, 4. F. winchelli** [Mich G S 3]. Longitudinal section and top view. **5. F. turbinatus** [Carnegie Mus, An 25]. Section of corallum (x2). **6–8. F. hamiltoniae.** Longitudinal section (x2) [Carnegie Mus, An 35]; top and side views [Pal N Y, Dev Corals]. **9, 10. F. canadensis.** Inclined view of a corallum [Geol Can 1863]; top view [Mich G S 3]. **11–13. F. placenta** [Mich G S 3; photographs furnished by G. M. Ehlers]. Two views of top and one of under surface. **14, 15. F. limitaris.** Loosely branching corallum [Mich G S 3]; corallum with tightly packed corallites [Ind G S 12]. **16, 17. Paleofavosites spp. 16. P. aspera** [CGS, Contr Can Pal 4]. Diagrammatic corallite (x5) showing pores along edge. **17. P. prolificus** [AJS (5) 17]. Diagrammatic view.

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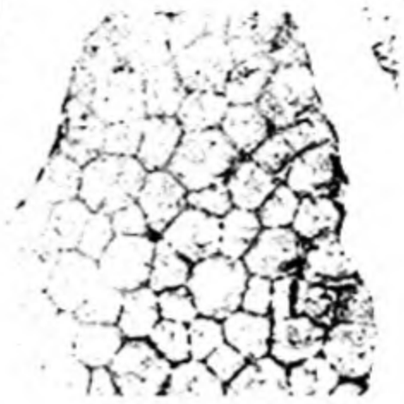

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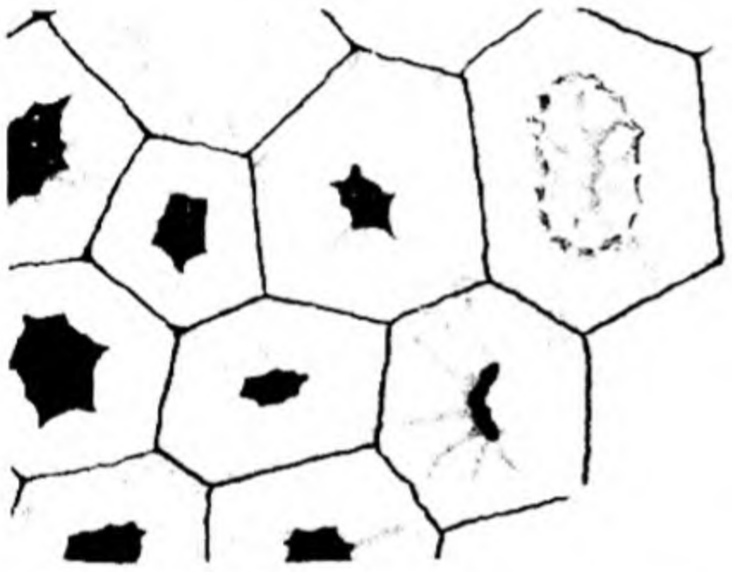

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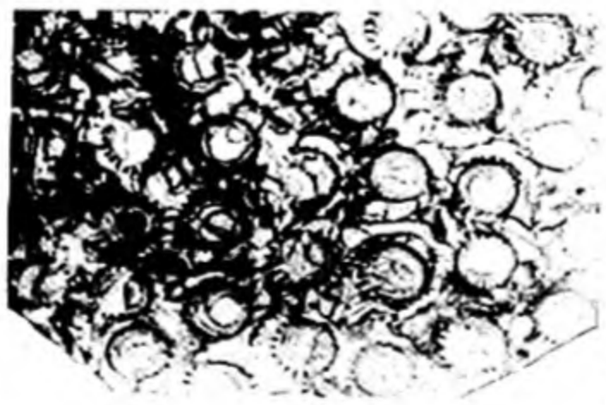

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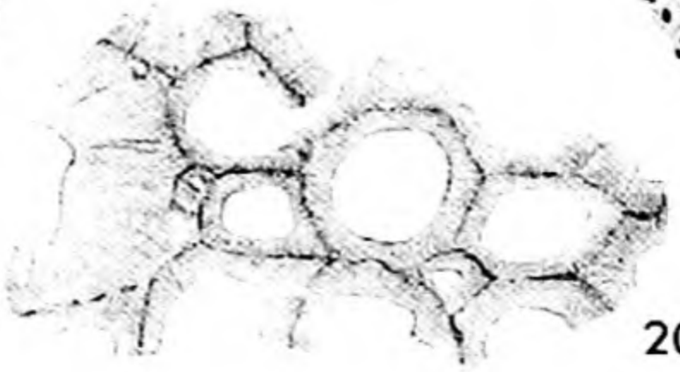

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communication, but communicating by long or short, much branched, anastomosing passages; pseudosepta or septal spines number 8 to 20, but may be absent; septa in some groups not homologous with septa of **Madreporaria,** for they are remnants of walls, not special outgrowths from corallite margins; some tendency to dimorphism. **Ord.–Recent.**

BILLINGSARIA Okulitch 1936

(= STYLARAEA Seebach 1866, TUMULARIA Robinson 1916)

(**Columnaria parva* Billings). Massive cerioid coralla forming flat expansions and possibly incrustations; corallites about 0.75 mm in diameter, short, opening to surface by rounded or polygonal calices of moderate depth; corallites communicate by a system of fine inosculating canals; eight primary and eight secondary septa, if present, extend into calyx but do not reach center, which is commonly occupied by a columella. **L. Ord.**

***B. parva** (Billings) (**35**—16–20). **Chazyan:** Mingan Islands, Que.; Lake Champlain region; Va., Tenn. (Lenoir, Holston).

PALEOALVEOLITES Okulitch 1935

(**Tetradium carterense* Bassler). Corallum massive, consisting of concentrically superimposed layers of contiguous compressed corallites which are thin-walled and open obliquely to the surface; in cross-section corallites are lunate, subtriangular, or irregularly polygonal; corallites 1.5 to 2.0 mm in greatest diameter; septa twelve to fifteen if present, reaching columella, into which they merge; tabulae flat and complete, at least two in distance of a corallite diameter; mural pores few, irregularly spaced, commonly present in lateral corners of corallites. **M. Ord.** (eastern N. America).

P. paquettensis Okulitch (**36**—1, 2). **Black River:** Ont.

ALVEOLITES Lamarck 1801

(**A. suborbicularis*). Corallum massive or arborescent; corallites thin-walled, closely appressed; calices oblique, compressed, triangular, or crescentic; septa rudimentary; tabulae complete, few; mural pores large but irregularly disposed. **Sil., Dev.**

A. undosus Miller (= **A. niagarensis** Rominger) (**36**—9). Corallum a hemispherical mass of concentric laminae with peritheca on lower side; the large marginal pores cause a pouchlike dilation of coral-lites. **Niagaran:** Que.; Mich., Ohio, Ky., Tenn.

A. squamosus Billings. Differs from *A. undosus* in the greater horizontal expansion (12.5 to 15 cm = 5 to 6 in.) as compared with the thickness (25 mm), in the great obliquity of apertures, and in absence of pouchlike protuberances; septal spines present; greatest diameter of corallites 0.5 to 1.0 mm. **Onondaga:** Ont.; N. Y., Mich., Ohio, Ky.

A. goldfussi Billings (**36**—6–8). Corallum flattened or discoidal expansion like *A. squamosus* with basal peritheca; corallites larger (1.5 to 2 mm), oblique, and in various stages of compression in same specimen. **Hamilton:** Ont.; N. Y., Mich. (Widder), Ia., Ky.

Appendix to Alcyonaria: "Tabulata"

An artificial subdivision of Anthozoa, including corals with corallum invariably composite, consisting of tubular or prismatic corallites; walls thick, independently calcified, compact or perforated by mural pores; septa but slightly developed or absent; interior of corallites partitioned off into successive chambers by tabulae; cystose structure may occur. **Paleozoic.**

It is altogether possible, as some investigators have suggested, that many genera included in this convenient repository belong to the Alcyonaria (e.g. FAVOSITIDAE, HALYSITIDAE, and SYRINGOPORIDAE).

FAVOSITES Lamarck 1816

(**F. gothlandicus*). Corallum branched, expanded or massive and commonly half a meter in diameter; corallites prismatic, thin-walled, in contact but not amalgamated; corallite walls perforated by pores; septa absent or represented by ridges or rows of spines, their condition varying greatly within individual coralla and corallites in some cases, but uniform for species in others; tabulae dominantly complete and approximately horizontal. **Ord.–Perm.** (distribution worldwide; no **Penn.** or later species from N. America).

F. favosus (Goldfuss) (**36**—10–12). Corallites large, up to 6 mm in diameter, with inside marked by 12 longitudinal furrows and by granulations; tabulae granulose, with their margins deflected into 12 (more or less) pits or notches corresponding to longitudinal furrows; marginal pores commonly in more than two rows. **Sil.** (U. Cataract–Niagaran): Anticosti to Wis., Ia., and Mo.; N. Y. to Ala.

PLATE 38

[Figures are x1 unless otherwise indicated.]

1–7. Emmonsia spp. 1–5. E. emmonsi. 1, 2: A typical corallum and an enlarged longitudinal section (x2) [Pal N Y, Dev Corals]; 3–5: Sections (x2) [Carnegie Mus, An 25]. **6, 7. E. tuberosa.** Portion of surface (x10) [Carnegie Mus, An 25]; complete corallum showing two sizes of corallites [Pal N Y, Dev Corals]. **8, 9. Thamnopora carbonaria** [DUB, JSL 18]. Exterior and longitudinal section. **10–15. Caliapoecia spp. 10. C. canadensis** [Nat Mus Can, B 80]. Neotype (x0.6). **11–15. C. canadensis anticostiensis.** 11, 12: Diagrammatic sections (x2.5) showing some varietal features [CGS, Contr Can Pal 4]; 13–15: Longitudinal and cross sections (x1.1) and portion of surface (x0.6) of Billings' holotype of "*C. anticostiensis*" [Nat Mus Can, B 80]. **16–21. Trachypora spp. 16, 17. T. elegantula** [Pal N Y, Dev Corals]. Exterior and longitudinal section somewhat enlarged. **18–20. T. austini** [Ill G S 8]. Exterior, and sections enlarged. **21, 22. T. ornata** [Pal N Y, Dev Corals]. A typical corallum and portion enlarged several times.

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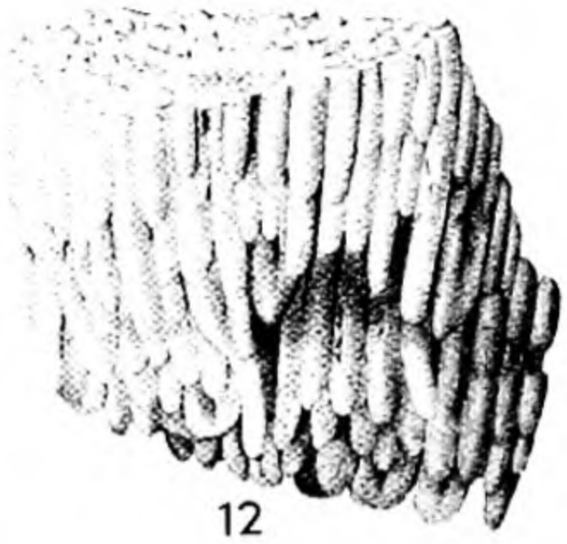
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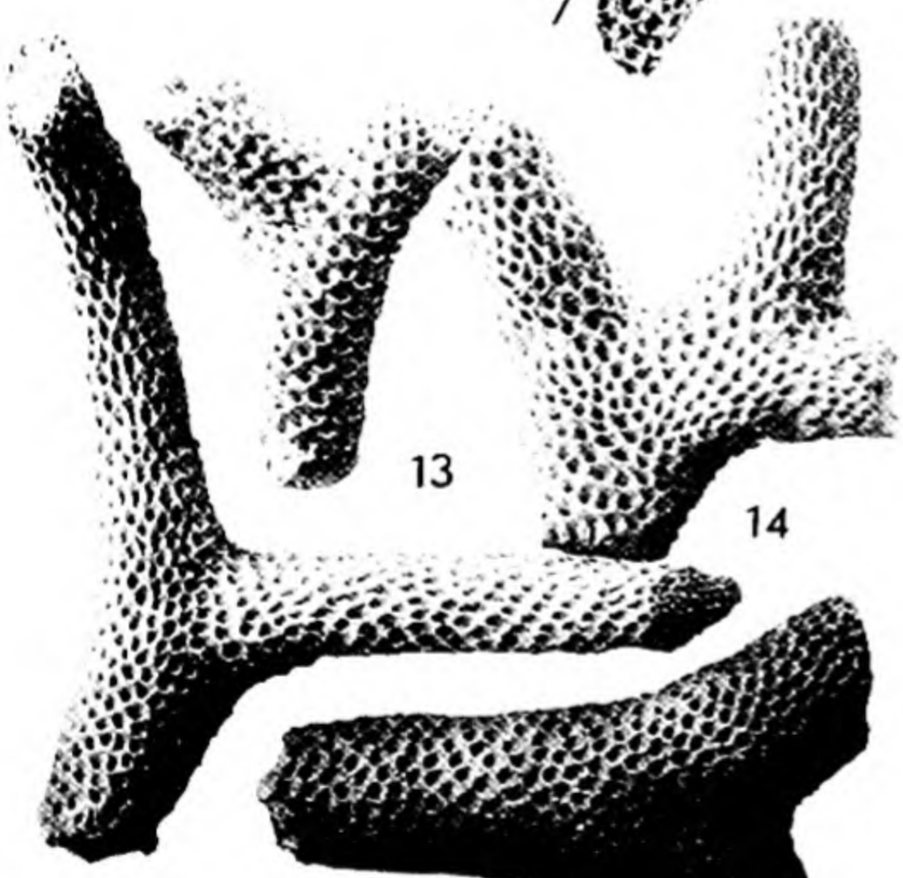
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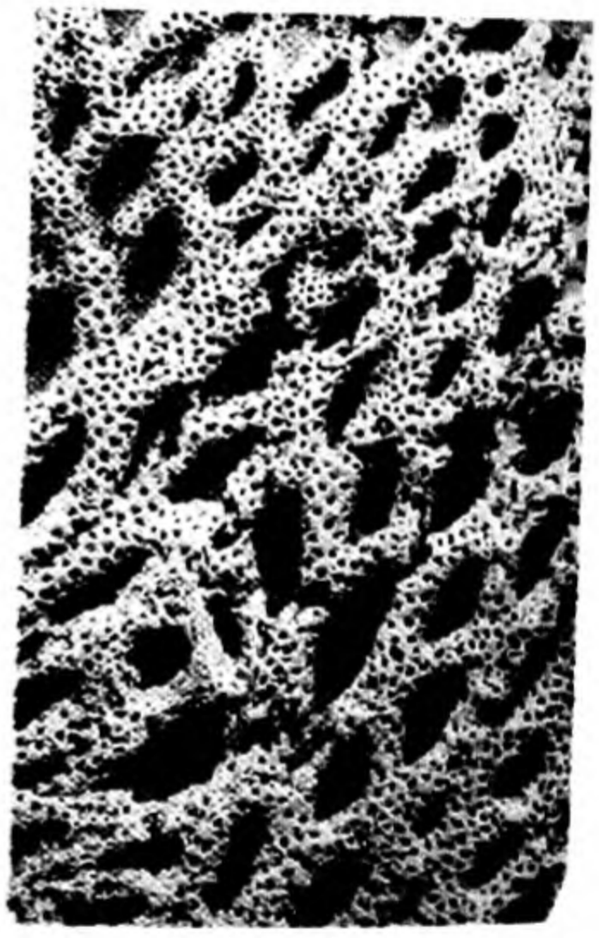
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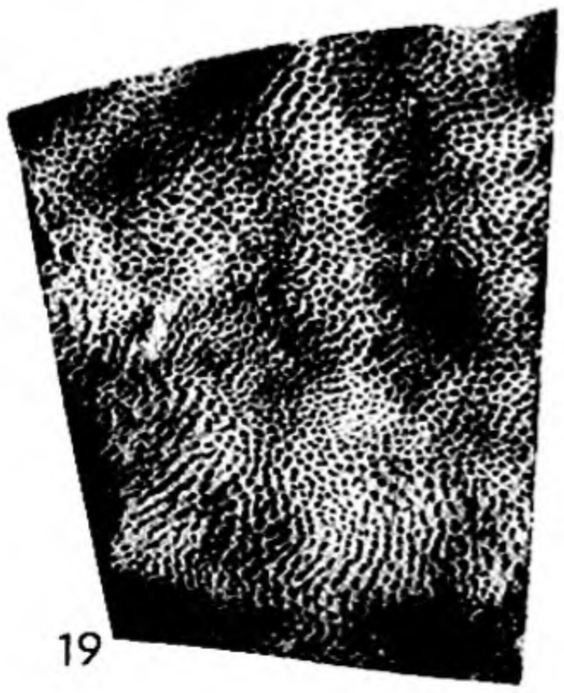
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F. niagarensis Hall (**36**—13–17). Corallum spheroidal or club-shaped; corallites much smaller than in *F. favosus* (about 1.5 mm in diameter); tabulae rarely notched at margin; mural pores on sides of corallites; inner surface of corallites delicately spinose. **Niagaran:** N. Y. [This species has also been reported from the Niagaran of Ontario, and from widely distributed formations of that age throughout N. America, but Ehlers (personal communication) believes the species should be confined to New York.]

F. helderbergiae Hall (**37**—1, 2). Coralla lenticular or hemispheroidal, often large, and with base covered by strongly wrinkled peritheca; corallites about 1.5 mm in diameter with strong longitudinal ridges; mural pores on sides of corallites in one or two rows, with elevated rims; tabulae close; the principal difference between this species and *F. niagarensis* appears to be in shape of corallum. **Helderbergian:** N. Y. to Tenn.; **Oriskany:** Miss. (Island Hill).

F. winchelli Rominger (**37**—3, 4). Corallites 3 to 4 mm in diameter; tabulae depressed at margins into several pits; not infrequently the whole septal rim is turned down; interior of corallites with 12 well marked longitudinal furrows; without squamae; mural pores in one to two rows on each side. **Onondaga:** Ont.; N. Y., Mich., Ky. (Falls of Ohio); **Hamilton:** Mich.

F. turbinatus Billings (= **F. hemispherica** of American authors) (**37**—5). Corallum turbanlike, often resembling cyathophylloid corals in being cuplike; generally curved in basal portions and frequently resembling the internal filling of a large pelecypod shell; corallites curve outward, with their mouths nearly perpendicular to main axis of corallum, average one to two mm in diameter, and are closed in perfect specimens by concentrically striated opercula; pores generally in single rows; tabulae complete, averaging 1.5 mm apart; squamae generally not prominent. **Onondaga, Hamilton:** Ont.; N. Y. to Ky., Mich.

F. hamiltoniae Hall (**37**—6–8). Corallum a hemispherical head with base covered by wrinkled peritheca; adult corallites up to 2.5 mm in diameter, generally surrounded by smaller immature ones; mural pores in two rows, frequently obscure; tabulae perfect, sometimes crowded, more generally 2 to 4 mm apart, not infrequently with marginal notches; easily recognized by its perfect tabulae. **Hamilton:** Ont.; N. Y., Ohio.

F. canadensis (Billings) (**37**—9, 10). Corallum generally a flattened or undulating expansion, sometimes digitate; cylindrical corallites about 1 mm in diameter, scattered irregularly between small angular ones about a third their size; simple tabulae in smaller corallites and tabulae complicated by squamae in the larger; opercula often present. **Onondaga:** Ont.; N. Y., Mich., Ind., Ky.

F. placenta Rominger (**37**—11–13). Corallum a broad, generally thin undulating expansion with base covered by wrinkled epitheca; corallites less than 1 mm in diameter with clusters of smaller ones scattered about; in some specimens (especially young ones), the larger corallites are cylindrical and widely separated, as in *F. canadensis*; tabulae of smaller corallites simple, of larger ones squamose; pores uniserial. **Hamilton:** Ont.; N. Y., Mich., Ohio.

F. limitaris Rominger (**37**—14, 15). Corallum a cylindrical, commonly branching stem 10 to 50 mm in diameter; corallites circular in section, opening about perpendicularly to axis of branch; walls thick; the division lines between corallites shown only in certain states of preservation. **Onondaga:** Ind. and Ky. (Jeffersonville).

PALEOFAVOSITES Twenhofel 1914

(**Favosites aspera* Orbigny).[1] Like *Favosites*, but with mural pores at extreme edges of sides of corallites; edges of corallites, at pores, extended beyond their normal positions to extent of slightly indenting adjacent sides. **Ord., Sil.** (Anticosti; Man.; Wyo.).

P. prolificus (Billings) (**37**—17). **Ord., Sil.:** Anticosti.

EMMONSIA Edwards and Haime 1851

(**Emmonsia hemisphaerica* Edwards and Haime [not *Calamopora hemispherica* Troost] = *Favosites emmonsi* Hall). Like *Favosites*, but with tabulae degenerate, chiefly represented by discrete, flattened projections (squamulae) which appear as spines in longitudinal section. **Dev.**

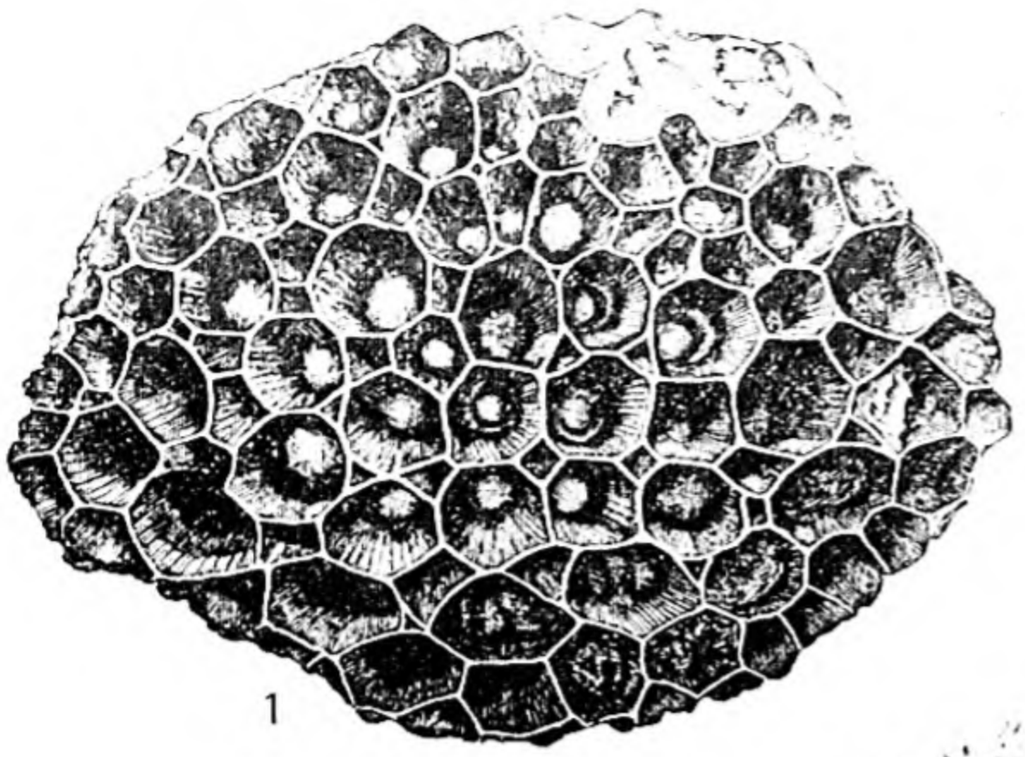
***E. emmonsi** (Hall) (**38**—1–5). Characterized by two to three rows of pores on each corallite face and

[1] Twenhofel (1914, 24) first designated *F. aspera* (**37**–16) as the genotype of his new genus, but later (1916, 125) he stated: "*F. asper* [*a*] was originally given as the genotype, this being done in the belief that it and *F. prolificus* are the same species. As there is some doubt in the author's mind that such is the case, it is thought that *F. prolificus* should be taken as the genotype."

PLATE 39

[Figures are x1 and after Rominger [Mich G S 3] unless otherwise indicated.]

1, 2. Thecia major. Upper and lower surfaces. **3, 4. Dendropora ornata.** Fragmental coralla. **5–8. Striatopora** spp. **5, 6. S. flexuosa** [Pal N Y 2]. Enlarged corallites and a branching specimen. **7. S. bellistriata. 8. S. iowensis.** Fragmental specimen. **9–19. Coenites** spp. **9, 10. C. spinulata** [USGS, PP 58]. An incomplete specimen and section enlarged (x4). **11, 12. C. seriata** [Pal N Y 2]. Enlarged branch and incomplete corallum. **13–16. C. cryptodens.** Fragmental specimens. **17. C. labiosa.** A group of fragmental specimens. **18. C. laqueata. 19. C. fischeri.** Portion of a corallum. **20–27. Pleurodictyum** spp. **20, 21. P. eugeneae** [Kan G S 6]. Two views of a corallum. **22–24. P. stylofloporum** [Pal N Y, Dev Corals]. View of several corallites somewhat enlarged, and top and side views of corallum. **25–27. P. lenticulare** [Pal N Y 6]. Side, top, and basal views of three different specimens.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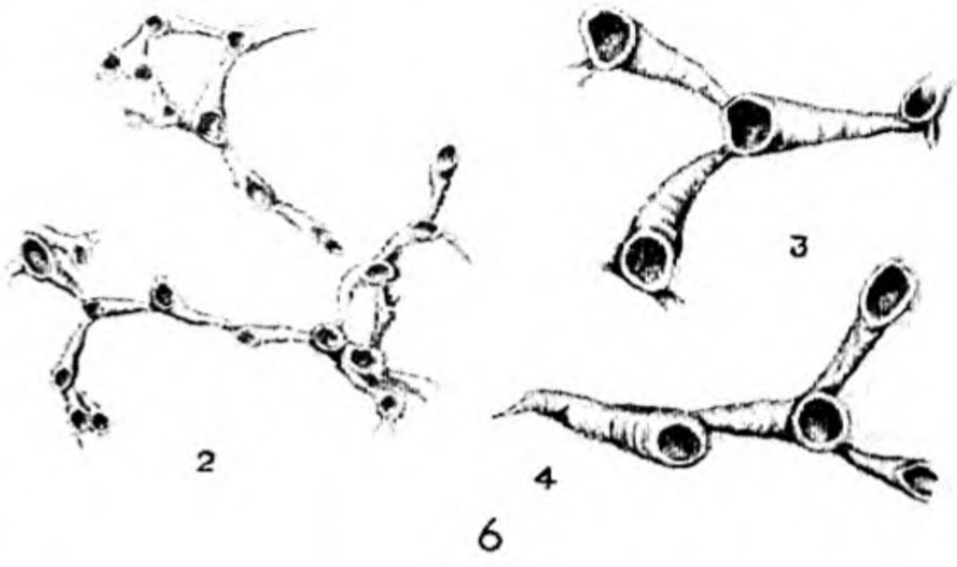
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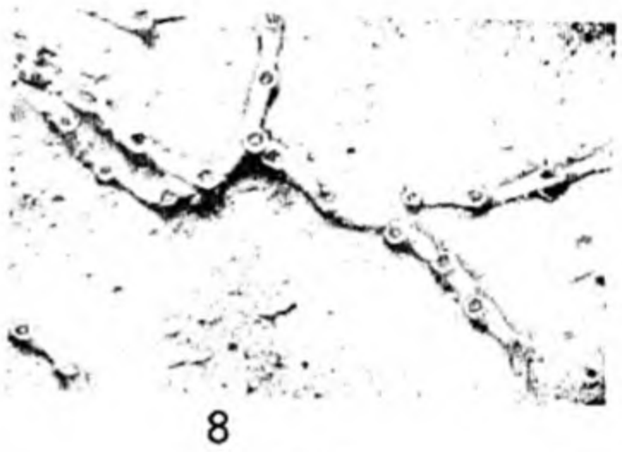
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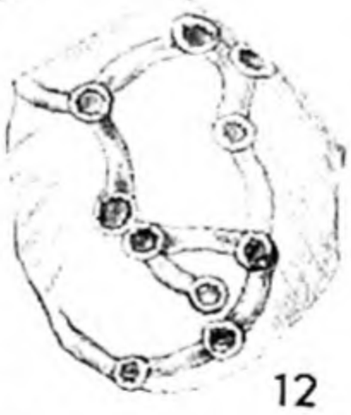
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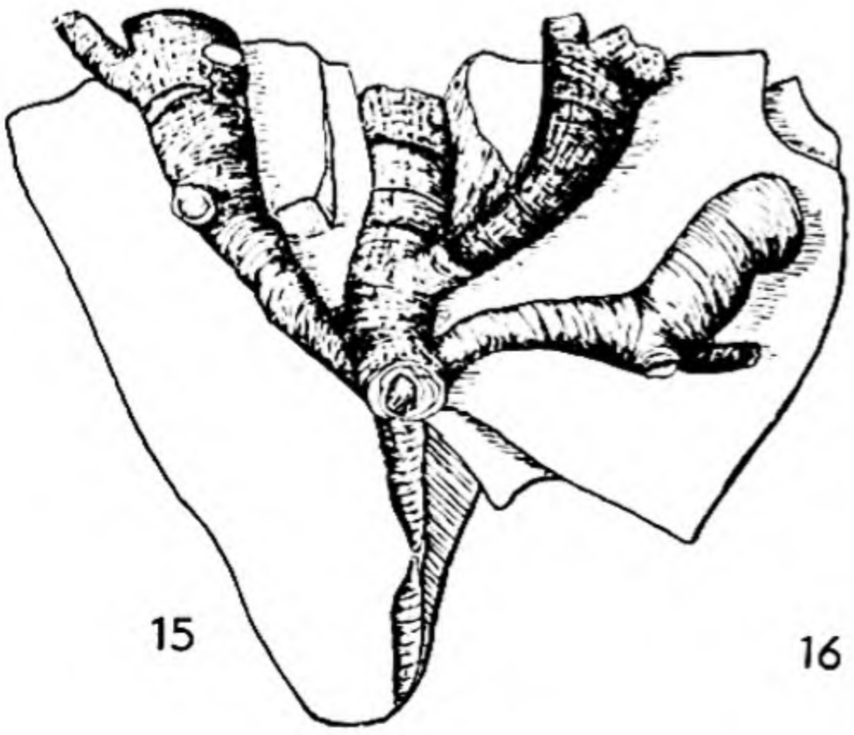
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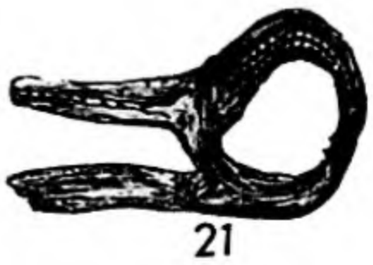
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marginally thickened squamulae. **Onondaga:** Ont.: N. Y.; Falls of Ohio.

E. tuberosa (Rominger) (**38**—6, 7). Corallites of medium size (2 to 3 mm in diameter); two to three rows of mural pores on each face, and two rows of stout horizontal squamae on inside of each face; squamae of adjoining rows alternating and often interlocking; pores surrounded by small pits; many corallite openings are closed by concave, concentrically wrinkled opercula. **Onondaga:** Ont.; N. Y., Ohio Valley.

E. epidermata (Rominger). Differs from *Emmonsia tuberosa* in irregular arrangement of squamae and in elevated ring around the small distant pores, which are rarely in more than two rows; interior of corallites with 12 longitudinal furrows which are commonly visible in reverse on outside of solid columns; squamae are on spaces between grooves; tabulae complete. **Onondaga:** Ont.; N. Y.

THAMNOPORA Steininger 1831

(? = PACHYPORA Lindström 1873)

(**T. madreporacea*). Corallum cylindrical or ramose; corallites disposed obliquely around central axis of fingerlike branches; cells communicate by pores. **Penn.** (Midcontinent).

T. carbonaria (Mather) (**38**—8, 9). **Morrow:** Ark., Okla.

CALAPOECIA Billings 1865

(**C. anticostiensis*). Corallum massive, hemispheroidal, spheroidal or incrusting; corallites polygonal or circular in cross-section; walls composed of fused septal elements, with pores on vertical and horizontal rows, alternating with the septa; septa typically 20, wedge-shaped, radiating, of equal length, short, usually extending 0.2 or less of diameter into corallite, inclined slightly upward; tabulae well developed, complete and incomplete; no dissepiments; if coenenchyma is present, 20 "costae" radiate from corallites; buds arise from between corallites. **Ord., Sil.** (Alaska eastward to Siberia, excluding British Isles; Ky. northward to Washington Land in northwestern Greenland; characteristic of post-Trenton and Richmond strata).

C. canadensis anticostiensis Billings (**38**—11–15; see also **38**—10). Corallites circular, more or less distant; coenenchyma and "costae" present. **M. and U. Ord.:** Ellesmere Land; Anticosti; Ont.; Alaska (Seward Peninsula); Norway; Sweden; Gotland. **Sil.:** Que. (Whitehead).

THECIA Edwards and Haime 1849

(**Porites expatiatus* Lonsdale = *Agaricia swinderniana* Goldfuss). Generally massive coralla composed of prismatic, thick-walled corallites with funnel-shaped calices; base with wrinkled peritheca; septa 12, strong, uniting in adjoining calices across intervening space; tabulae and mural pores as in *Favosites*. **Sil., Dev.**

T. major Rominger (**39**—1, 2). Corallites 2 mm in diameter; septa extend halfway to center, their edges with two rows of granulose spinules. **Niagaran:** Ont.; Mich., Ind., Ky., Tenn .

T. minor Rominger. Corallites about 1 mm in diameter; otherwise similar to preceding, with which it occurs.

TRACHYPORA Edwards and Haime 1851

(**T. davidsoni*). Corallum consisting of branching cylindrical stems, which are composed of prismatic corallites, the walls of which are so thickened by layers of stereoplasm that the apertures become round and greatly contracted and thus are superficially far apart; mural pores scattered; tabulae remote; rows of spines representing the septa are characteristic. **Dev.–Penn.**

T. ornata Rominger (**38**—21, 22). Stems 10 to 20 mm in diameter; apertures circular or oval, generally slightly elevated, irregularly dispersed, the interspaces wider than the diameter of the aperture, which is 1.5 mm; granules and short radial ridges surround the apertures. **Hamilton:** Ont.; N. Y., Mich.

T. elegantula Billings (**38**—16, 17). Stems 2 to 5 mm in diameter; apertures in four rows, oval, and partly edged by an elevated rim. **Hamilton:** Ont.; N. Y., Mich., Ohio, Ky.

T. austini Worthen (**38**—18–20). **Penn.:** Kan.

STRIATOPORA Hall 1851

(**S. flexuosa*). Corallum of simple, dividing cylindrical branches, with thick-walled corallites opening in rounded apertures; these apertures are funnel-shaped because the surrounding stereoplasm increases in depth; sides of apertures striated by rudimentary septa; occasional septal spines, tabulae, and mural pores. **Sil., Dev.**

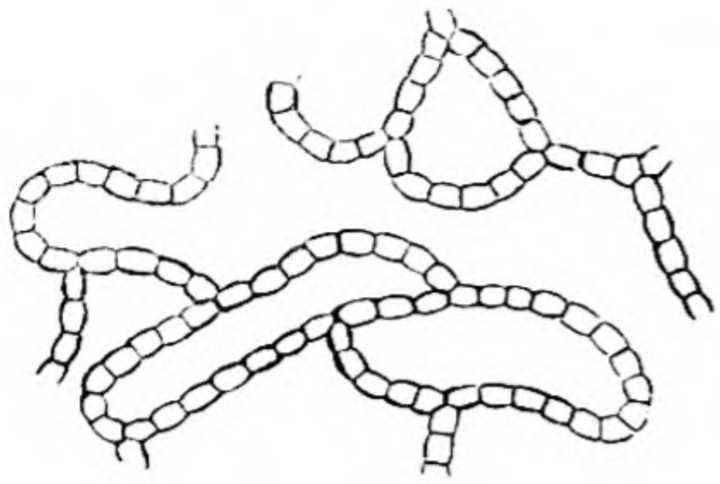
***S. flexuosa** Hall (**39**—5, 6). Branches bifurcating; polygonal expansion of corallites deep, bounded by angular ridges, vertically striate, the striae becoming fainter upward; calices circular at base. **M. Sil.:** Ont. (Rochester); N. Y. (Clinton), Ind. (Osgood).

S. iowensis (Owen) (= **Cyathopora iowensis** =

PLATE 40

[Figures are x1 unless otherwise indicated.]

1–4. Pleurodictyum spp. **1–3. P. convexum** [Pal N Y, Dev Corals]. A large corallum, longitudinal section, and calicular view showing arched tabulae (x0.5). **4. P. cylindricum** [Carnegie Mus, An 25]. **5–9. Aulopora** spp. **5. A. conferta** [Am Mid Nat 18]. A typical colony attached to a coral (x2). **6. A. elleri** [Am Mid Nat 18]. Several coralla (2 is x1 and the holotype; 3 and 4 are x2). **7, 8. A. modulata** [Am Mid Nat 18]. A fragmental colony (x2), and the holotype showing coralline tubes. **9. A. anna** [Kan G S 6]. **10, 11. Romingeria umbellifera.** A group of fragmental coralla [Mich G S 3]; two diagrammatic fragments [Geol Can 1863]. **12, 13. Aulocaulis** spp. [Am Mid Nat 18]. **12. A. annectens.** Holotype. **13. A. expansus.** Holotype. **14. Aulopora michiganensis** [Am Mid Nat 18]. Portion of holotype attached to the surface of a stromatoporoid. **15–17. Ceratopora jacksoni** [NAIF]. A corallum, and sections (x2) of corallites showing internal structure. **18–21. Cladochonus beecheri** [NAIF]. Two fragmental coralla, an enlarged cross section, and portion of latter further enlarged.



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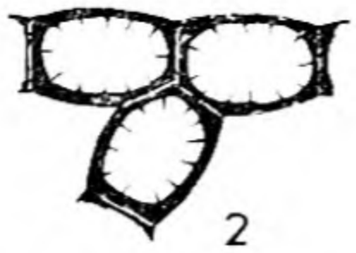

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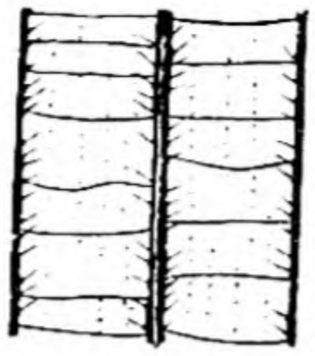

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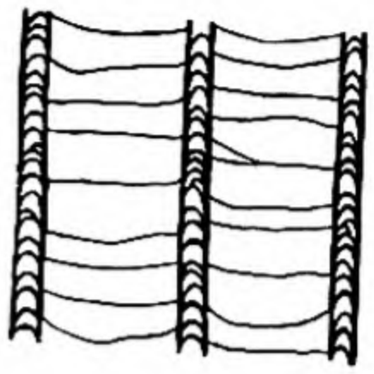

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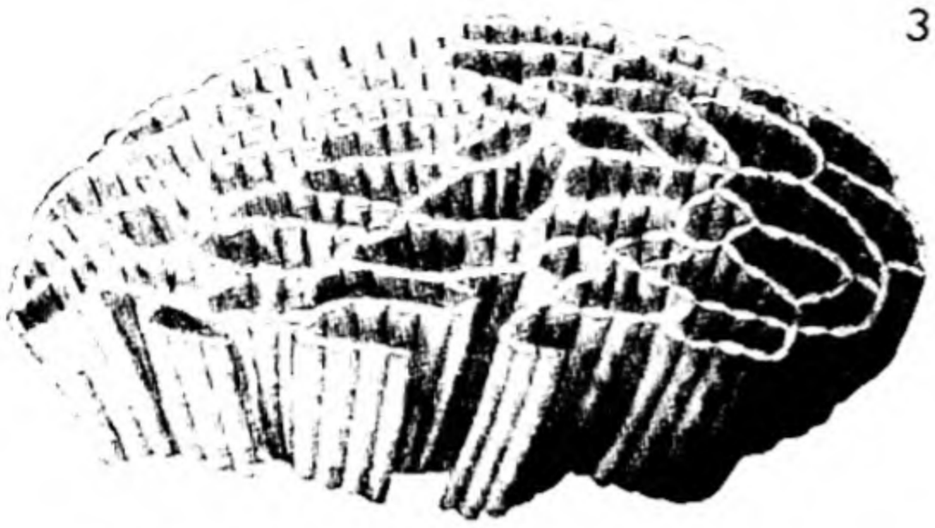

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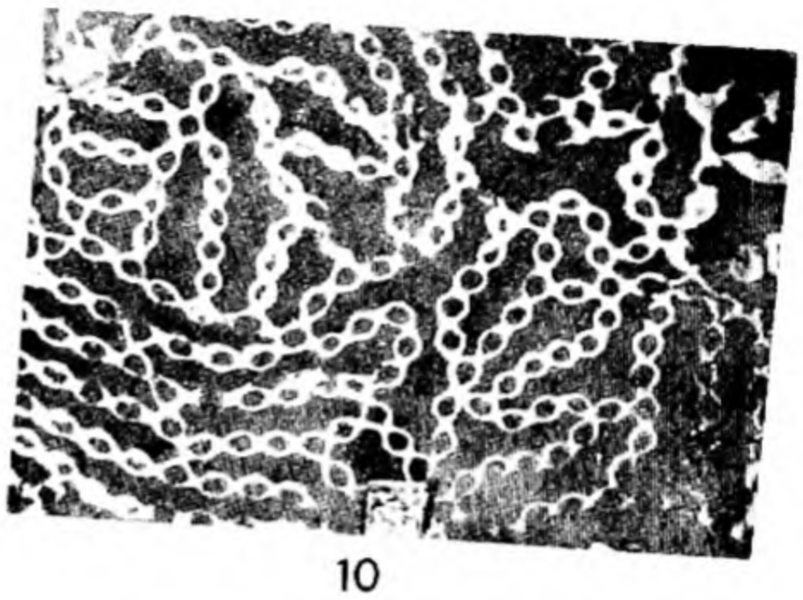

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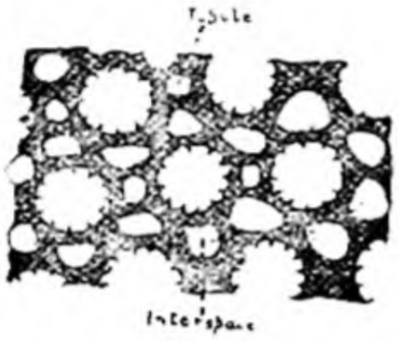

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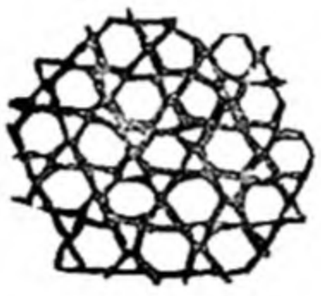

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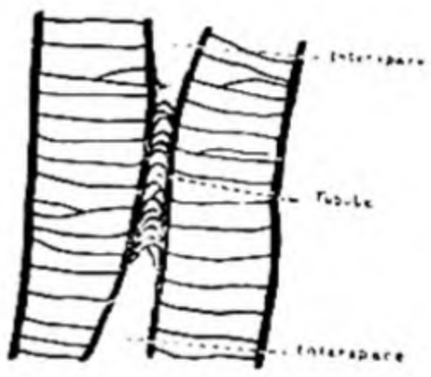

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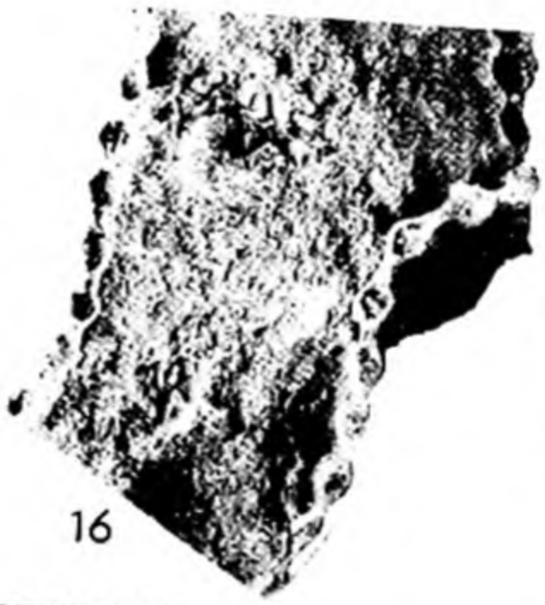

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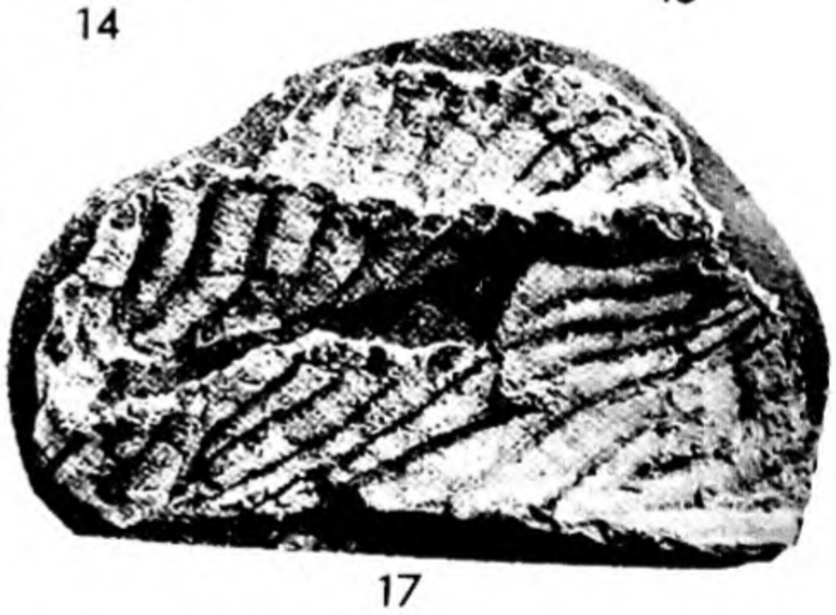

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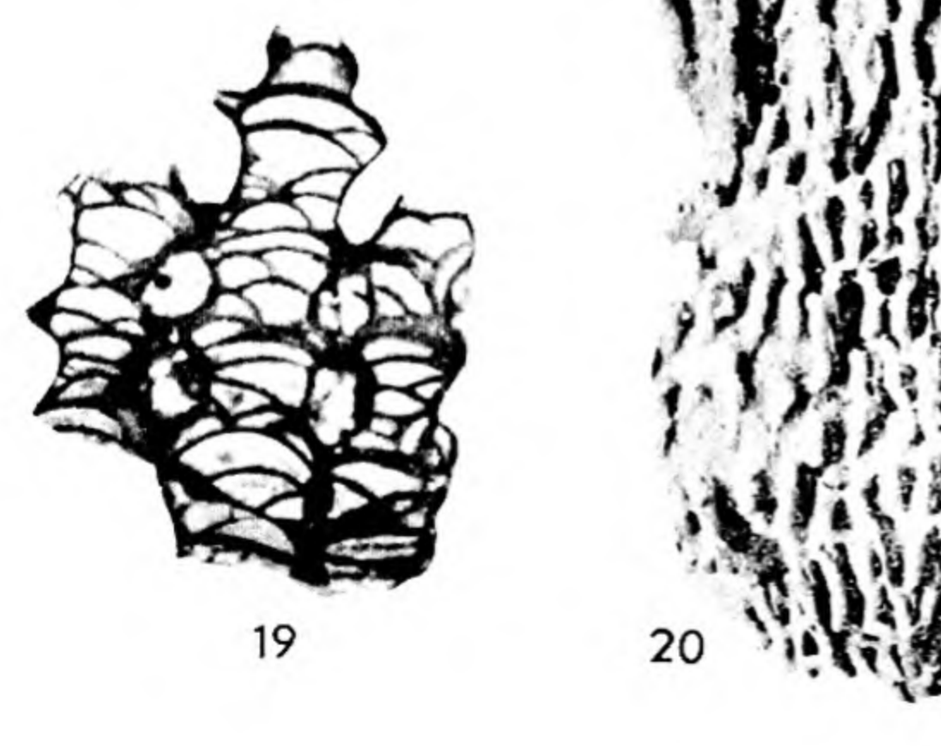

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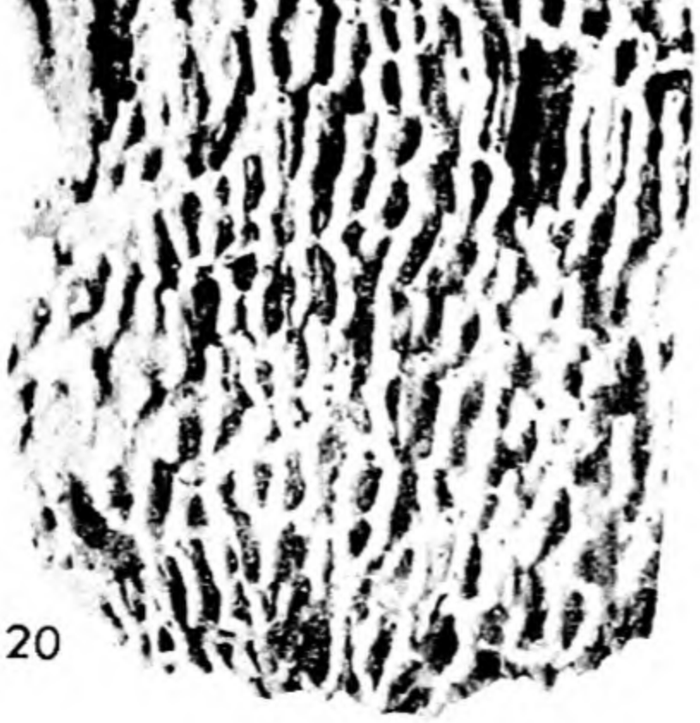

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S. rugosa Rominger) (**39**—8). Stems 5 to 12 mm in diameter, irregular; apertures oblique, dilated, bounded on exterior side by a pronounced semicircular lip; inner body side of aperture flattened, spreading into a common, broad, interstitial mass; diameter of aperture 2 mm, of interior channel, 1 mm, striae generally faint or obsolete. **Hamilton:** Mich., Ia.

S. bellistriata Greene (**39**—7). **Jeffersonville:** Ind., Ky.

DENDROPORA Michelin 1846

(**D. explicita*). Branching and reticulated stems composed of thick-walled, intimately united conical, tabulate tubules, which are connected laterally by pores. **Dev.** (eastern N. America).

D. ornata Rominger (**39**—3, 4). **M. Dev.:** Ont.; N. Y., Mich.

COENITES Eichwald 1829

(= CLADOPORA Hall 1851)

(**C. juniperinus*). Corallum composed of branching stems or flattened expansions with thick-walled, elongate, conical corallites opening obliquely to the surface, with dilated openings; mural pores and occasional tabulae present. **Sil., Dev.**

C. seriata (Hall) (**39**—11, 12). Nearly parallel crowded branches, sometimes bifurcating; calices in alternating series with projecting circular lip. **Niagaran:** Ont.; N. Y.

"C." laqueata Rominger (**39**—18). Corallum composed of cylindrical or compressed stems 2 to 4 mm in diameter, uniting repeatedly to form a coarse network; corallite apertures oval, transverse to branches, about 1 mm across, and with strong lip. **Niagaran:** Que., Ont.; Mich., Ind., Ky.

"C." cryptodens (Billings) (**39**—13–16). Cylindrical bifurcating branches 5 to 10 mm in diameter; corallites with oblique, dilated apertures 1 to 1.5 mm in diameter. **M. Dev.** (Onondaga): Ont.; N. Y., Mich., western States.

"C." labiosa (Billings) (**39**—17). Stems smaller and frequently branching, often reuniting; apertures subcircular, oblique, 2 to 5 mm in diameter, with prominent convex lip. **Onondaga:** Ont.; N. Y., Mich., Ohio, Ky. (Falls of Ohio).

C.? fischeri (Billings) (**39**—19). Corallum a flat, leaflike expansion attached at some point to a foreign body; with oblique apertures on both sides. **Onondaga, Hamilton:** Ont.; Mich., Ind., Ky.

C. spinulata (Girty) (**39**—9, 10). **Perm.:** Tex. (base of Capitan; Delaware Mt.; "dark limestone" in Guadalupe Mts.; Delaware Mt. in Glass Mts.).

PLEURODICTYUM Goldfuss 1829

(= MICHELINIA Koninck 1841)

(**P. problematicum*). Corallum depressed, discoidal, with lower surface covered by concentrically wrinkled peritheca; corallites small, prismatic, funnel-shaped; septa faint or obsolete; scanty development of tabulae; mural pores irregularly distributed; young corallites as in *Aulopora*. **Dev.–Penn.**

P. lenticulare (Hall) (**39**—25–27). Diameter of corallites 5 to 6 mm. **Helderbergian:** N. Y., Pa., Tenn. (Oriskany).

P. styloporum (Eaton) (**39**—22–24). Coralla 25 to 50 mm in diameter; septa faint, forming a crenulation on the calyx margin; tabulae moderately numerous. **Hamilton:** N. Y., Mich., Ky. (Falls of Ohio).

P. convexum (Orbigny) (**40**—1–3). Calices diverge outward, 8 to 10 mm in diameter at aperture; tabulae thin, very close, strongly arched in center, vesicular at base. **Onondaga:** Ont.; Mich., Ky. (Falls of Ohio).

P. cylindricum (Michelin) (**40**—4). Corallum 10 to 12.5 cm (4 to 5 in.) in diameter; corallites subcylindrical, averaging about 5 mm in diameter; on the interior are regular annulations which occupy the same level in adjoining tubes; principal tabulae numerous, slightly arched, uniting with the incomplete ones. **Onondaga:** Mich., Ohio (Columbus), Ky. (Jeffersonville).

P. eugeneae White (**39**—20, 21). **Penn.:** Ill. (U. Carb.); Morrow, Wapanucka, Wewoka, Drum, etc., of Kan., Okla.

AULOPORA Goldfuss 1829

(**A. serpens*). "Form genus"; corallum composed of small tubes; adnate, prostrate, or prostrate basally with erect or more probably pendant compound branches; reproduction by basal or lateral gemmation; tubes calcareous or perhaps even chitinous, the former predominating; corallite walls noncystose, smooth to wrinkled externally, smooth or pustulose internally; tabulae, when present, variably convex adaperturally; corallites not continuously united except in rare instances in which calcification is incomplete. (Some species referred to this genus belong to Ceratopora Grabau 1899.) **Sil.–Penn.**

A. conferta Winchell (**40**—5) and **A. michiganensis** M. A. Fenton (**40**—14). **M. Dev.:** Mich. (Gravel Pt.).

PLATE 41

[Figures are x1 and after Lambe [CGS, Contr Can Pal 4] unless otherwise indicated.]

1–17. Halysites spp. 1–3. H. gracilis. A typical corallum, and sections enlarged (x5). **4–10. H. catenularia.** 4, 5: A typical corallum, and cross section enlarged (x5); 6–8: Sections enlarged (x5), and a typical specimen; 9: A typical corallum [Pal N Y 2]; 10: Surface showing arrangement of corallites [Tenn G S, B 38]. **11–14. H. compactus.** Cross sections (x2, x5); cross section (x2), and longitudinal section (x5). **15. H. microporus.** Diagrammatic cross section. **16, 17. H. labyrinthicus** [Ky G S, Ky Fos Corals]. Two views of a weathered corallum. **18, 19. Chonostegites clappi.** A weathered corallum [Pal N Y, Dev Corals]; a longitudinal section (x2) showing tabulae and tabular spines [Carnegie Mus, An 25]. **20, 21. Syringopora spp. 20. S. retiformis** [CGS, Mem 111]. Side view of Billings' type. **21. S. verticillata** [Mich G S 3].

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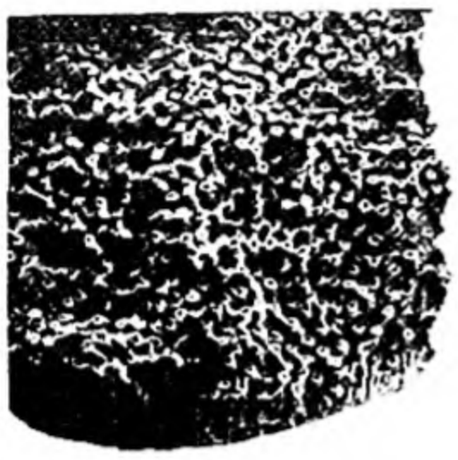

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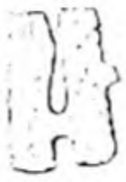

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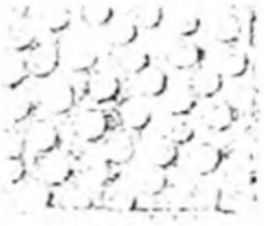

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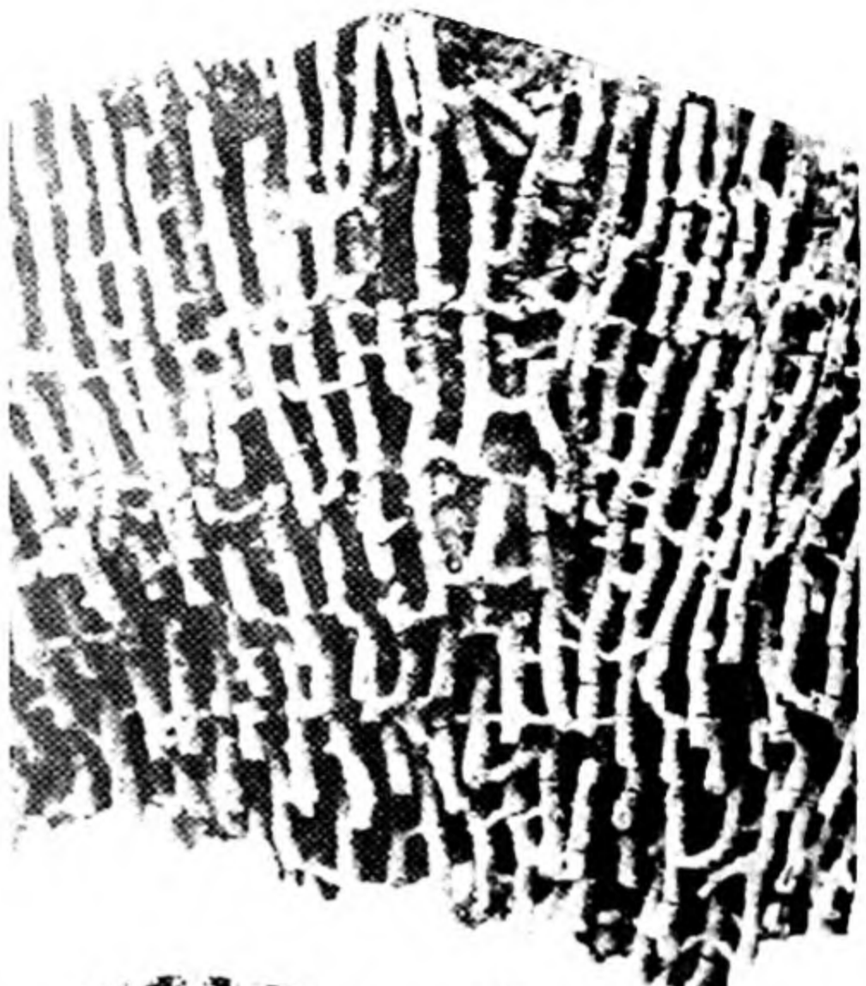

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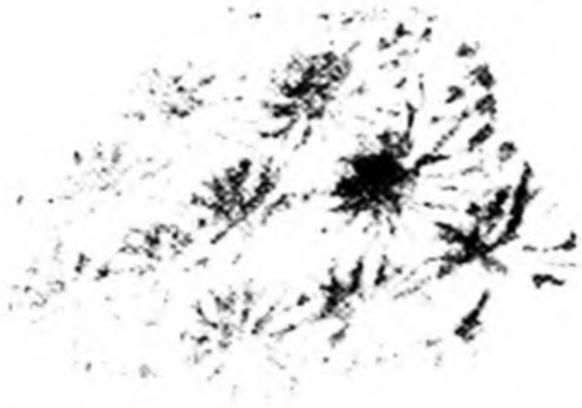

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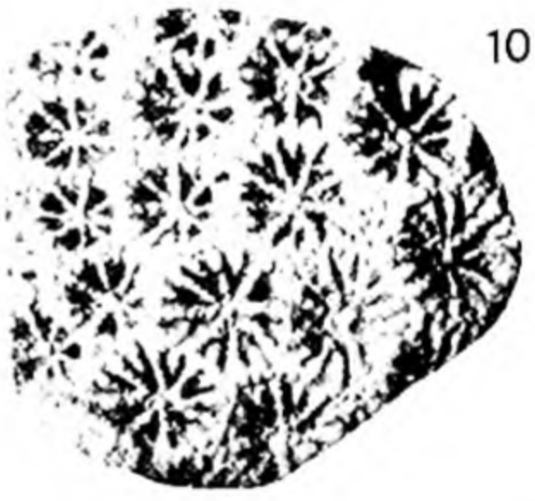

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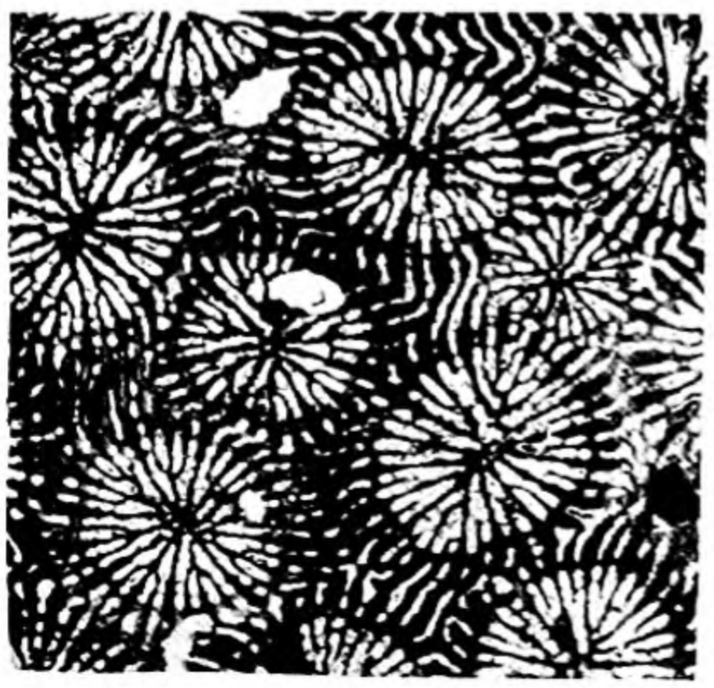

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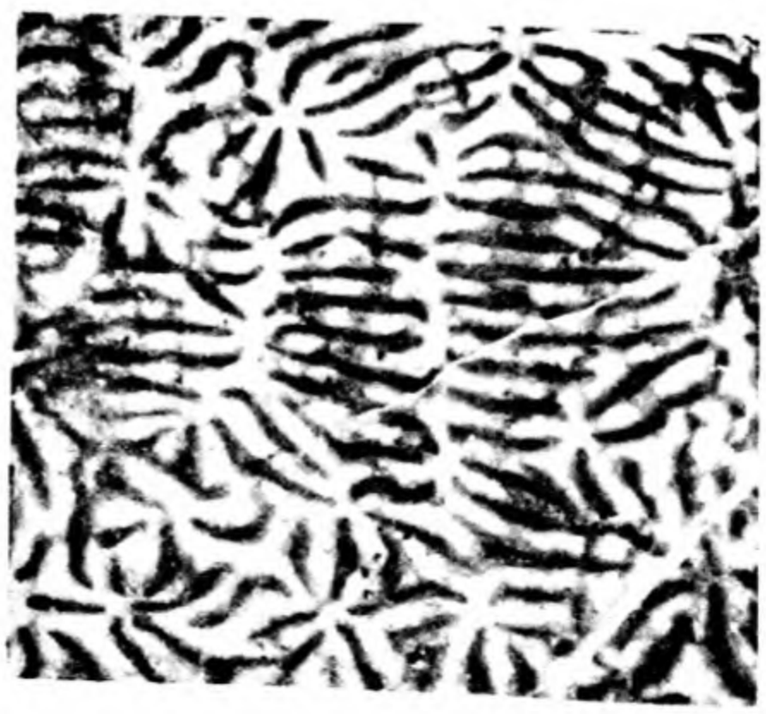

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A. elleri M. A. Fenton (**40**—6). **M. Dev.:** N. Y. (Hamilton).

A. modulata M. A. Fenton (**40**—7, 8). **U. Dev.:** Ia. (Shellrock).

A.? anna Beede (**40**—9). **U. Penn.:** Ind. (W. Franklin), Kan.

ROMINGERIA Nicholson 1879

(**Aulopora umbellifera* Billings). Auloporoid, with corallites budding off in whorls; tabulae remote; occasional mural pores present; growth erect. **Sil., Dev.**

***R. umbellifera** (Billings) (**40**—10, 11). Corallites about 1 mm in diameter; delicately annulate by growth lines; whorls consisting of 6 to 12 buds, remaining at first close together, then bent abruptly outward radially. **U. Sil.?:** Ont. **M. Dev.** (Onondaga-Hamilton): Ont.; N. Y., Mich., Ohio.

AULOCAULIS M. A. Fenton and C. L. Fenton 1937

(**Aulopora expansa*). Corallum prostrate, linear or reticulate; corallites thin-walled, depressed, smooth or indistinctly wrinkled; throughout most of their length they show little or no expansion; then they expand abruptly into subcircular apertural regions whose diameter is 1.5 to 4 times that of the tabular portions of the corallites; apertures are directed vertically and are but slightly elevated above the tubes; tabulae few or absent; septal ridges present; some species bear an indistinct dorsal ridge on most or all corallites; budding terminal; corallites with linear or branching disposition. **Dev.**

***A. expansus** (F and F) (**40**—13). **U. Dev.:** Ia. (Hackberry).

A. annectens (F and F) (**40**—12). **U. Dev.:** N. Y. (Naples).

CERATOPORA Grabau 1899

(**C. jacksoni*). Like *Aulopora* in appearance, but with tubes often much larger and never attached except at base; walls thickened by formation of coarse cysts, from the surface of which arise sharp spines; central space commonly open, the individual corallites remaining connected; epitheca generally well marked. **Dev.**

***C. jacksoni** Grabau (**40**—15–17). Branches budding at irregular intervals; corallites large and coarse, with longitudinal striation marking epitheca; cysts coarse and irregular. **Hamilton:** N. Y., Mich., Ohio.

CLADOCHONUS McCoy 1847

(= MONILOPORA Nicholson and Etheridge 1879)

(**C. tenuicollis*). External form similar to *Ceratopora*, but with wall composed of parallel layers separated slightly and connected by numerous transverse bars or trabeculae, which in section give a regular netlike appearance. **Dev.-Penn.**

C. antiqua (Whiteaves). Corallites slender; surface reticulate; free, or incrusting crinoids. **Hamilton:** Ont.; Ky. (Falls of Ohio).

C. beecheri (Grabau) (**40**—18–21). Free growing or incrusting crinoid stems, sometimes forming a confused agglomeration; epitheca smooth except for growth lines, structurally very dense, lacunae small and scattered. **Miss.** (Keokuk): Mississippi Valley region.

HALYSITES Fischer 1850

(**Tubipora catenularia* Linnaeus). Corallum of cylindrical or compressed corallites, joined into intersecting and anastomosing vertical laminae or single layers of tubes, and united along the whole of their adjoining sides; corallites covered by continuous peritheca on their free sides; mural pores absent; tabulae well developed; septa obsolete or in cycles of 12. **U. Ord., Sil.** (Arctic America; widespread throughout Canada and U. S. A.; Alaska), **L. Dev.**

H. gracilis (Hall) (**41**—1–3). Differs from *H. catenularia* in having corallites almost quadrangular in section and apparently lacking an intervening minute tube. **U. Ord.** (Richmond): Baffin Land; Anticosti; Que., Ont., Man.; Wis., Wyo. (Bighorn), Idaho (Fish Haven).

***H. "catenularia"** (Linnaeus) (= **H. catenulatus** of authors) (**41**—4–10). Corallites oval in section, united by their narrower sides, or with a minute, closely tabulate tube intervening; outer surface of corallites with fine and occasionally coarse growth lines; meshes formed by corallites irregular and variable in size. Widely distributed and common throughout the **Sil.** of N. America and Europe; varieties occur in the **U. Ord.** and **L. Dev.**

H. compactus Rominger (**41**—11–14). **Niagaran:** Ont.; Mich., B. C.

H. microporus (Whitfield) (**41**—15). **Niagaran:** Ont.; Wis.

H. labyrinthicus Goldfuss (**41**—16, 17). **Niagaran:** Ont.; Wis., Ky., Tenn.

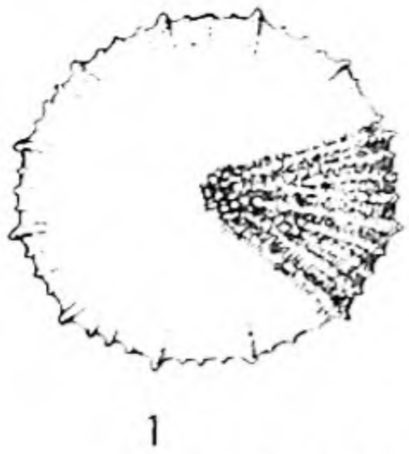
CHONOSTEGITES Edwards and Haime 1851

(**C. clappi*). Coralla composed of cylindrical corallites either closely adjoining or distinct and expanding at regular intervals into connecting horizontal plates, which are pierced by canal-like pores; tabulae as in *Pleurodictyum*; septa represented by

PLATE 42

[Figures are x1 unless otherwise indicated.]

1–12. Syringopora spp. 1, 2. S. hisingeri [Mich G S 3]. Side and top views. **3, 4. S. tabulata** [Mich G S 3]. Top and side views. **5–9. S. multattenuata.** 5–7: A fragmental corallum, several enlarged corallites (x2), and a cross section [McChesney: New Fos West States]. 8, 9: A group of corallites and two enlarged (x2) [Meek: Pal East Neb]. **10. S. perelegans** [Mich G S 3]. **11, 12. S. aculeata** [USGS, M 32]. Cross section of part of type, and of a single corallite much enlarged. **13–16. Astrocoenia spp. 13, 14. A. maloniana** [USGS, B 266]. Portion of a corallum, and some corallites enlarged (x6). **15. A. decaturensis** [USNM, B 103]. Calices (x5) of type. **16. A. whitneyi** [JP 6]. A group of calices (x4). **17–19. Diploastrea spp. 17, 18. D. crassolamellata** [GSL, QJ 19]. Portion of a calicular periphery, and a complete calyx. **19. D. harrisi** [JP 6]. Cross section of calices (x3). **20. Thamnasteria rectilamellosa** [USGS, PP 141]. Portion of polished cross section (x3). **21, 22. Astreopora antiguensis** [USNM, B 103]. Calices of paratype (x6) and corallum (x0.5).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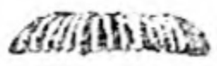
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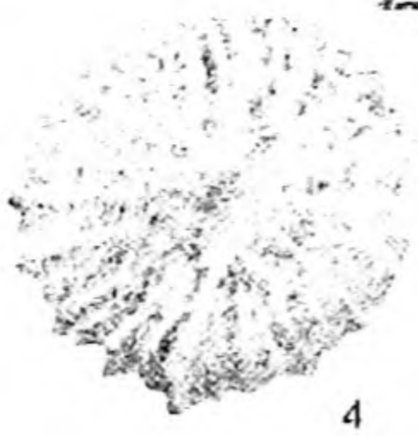
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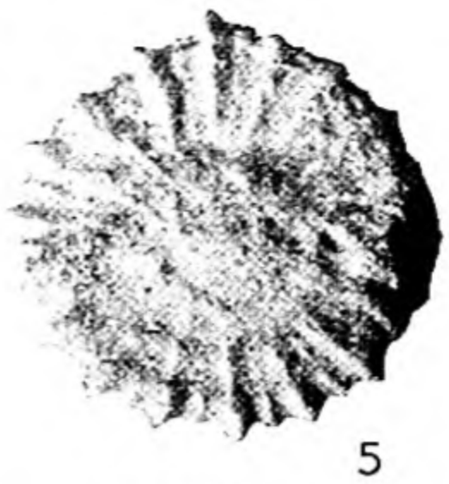
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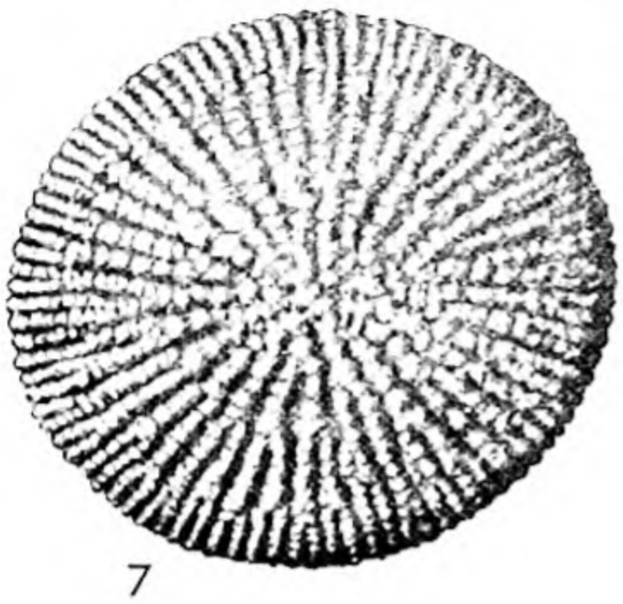
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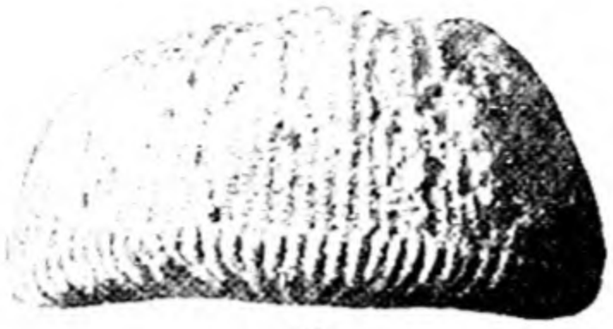
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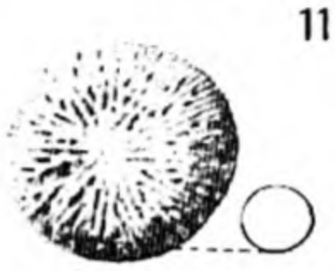
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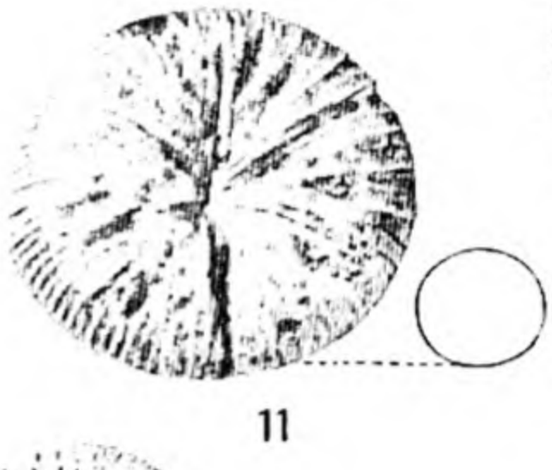
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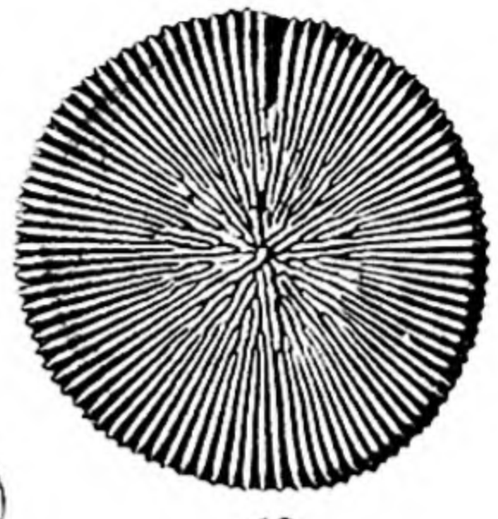
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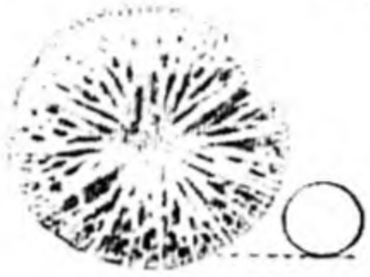
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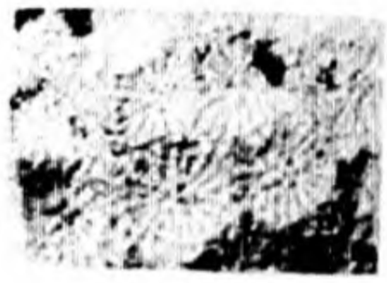
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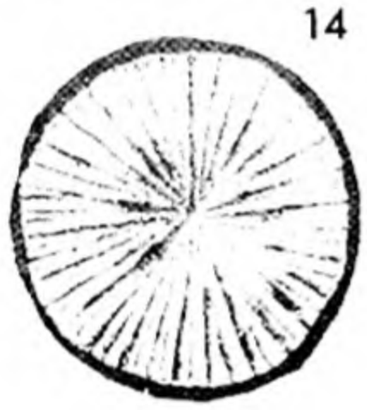
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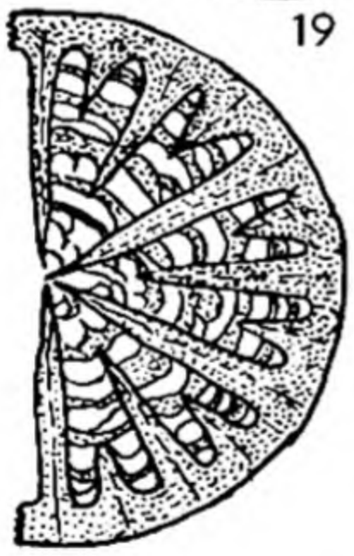
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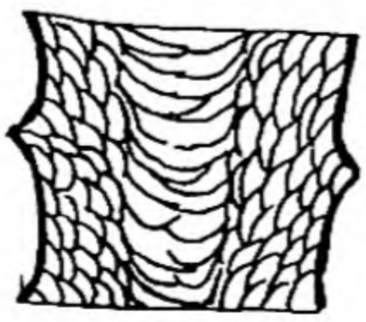
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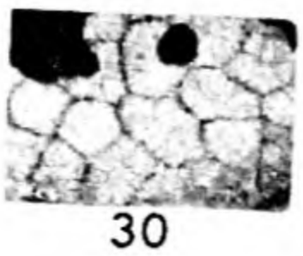
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rows of spinules; new buds arise from connecting plates. **Dev.**

***C. clappi** E and H (**41**—18, 19). Corallites 5 mm or more in diameter; connecting plates crowded, giving the whole a very compact appearance. **Onondaga:** Ont.; N. Y., Ohio valley.

SYRINGOPORA Goldfuss 1826

(**S. ramulosa*). Corallum consisting of numerous irregular cylindrical corallites, which grow parallel but generally separated and have at intervals a few transverse tubular connecting processes; interior of corallite filled with funnel-shaped tabulae; young as in *Aulopora*; septa represented by spines. **Sil.–Penn.**

S. verticillata Goldfuss (**41**–21). Corallites separated by one to three or more times their diameter (2 to 3 mm.), connected at distant intervals by transverse tubes of which two or three are given off at the same level. **Niagaran:** Arctic America; Anticosti; Que., Ont.; Mich. (Manistique).

S. retiformis Billings (**41**—20). Corallites 1 mm or somewhat less in diameter, irregularly bending or geniculate, joining where in contact but not by tubes. **Niagaran:** Ont.; N. Y., Wis.

S. hisingeri Billings (**42**—1, 2). Corallites are slender tubes less than 1 mm in diameter, separated by about their own width; frequent connecting tubes present. **Onondaga:** Ont.; N. Y., Mich., Ohio, Ind., Ky.

S. tabulata Edwards and Haime (**42**—3, 4). Corallites slender as in *S. hisingeri*, but closer together and parallel; connecting tubes at uniform levels, giving appearance of horizontal floors connecting corallites. **Onondaga:** Mich., Ohio, Ky. (Falls of Ohio).

S. perelegans Billings (**42**—10). **Onondaga:** Ont.; N. Y., Mich., Ky.

S. aculeata Girty (**42**—11, 12). Corallites small, radiating, usually about 1 mm apart; averaging about 1.5 mm in diameter; septa represented by spines set in about 25 vertical rows; dissepimental structures well developed, spinose. **Miss.** (Madison): Alta.; Colo., Wyo., Ariz.; **L. Penn.:** Alta (**S. surcularia** Girty, which occurs with *S. aculeata*, is somewhat larger, has walls more thickened by stereoplasm and has slightly larger corallites — 2.5 mm in diameter).

S. multattenuata McChesney (**42**—5–9). **Penn.:** Throughout Midcontinent region; Utah.

Subclass Hexacoralla

(= **Zoantharia** Blainville; **Hexactinia** and **Polyactinia** Ehrenberg)

Simple or composite corals with septa usually arranged in cycles of six (rarely five, seven, or eight). **Trias.–Recent.**

ASTROCOENIA Edwards and Haime 1848

(**Astrea numisma* Defrance). Coralla massive; corallites polygonal, united by their walls; columella styliform; only dissepiments in visceral chamber. **Trias.–Tert.**

A. maloniana Vaughan (**42**—13, 14). Calicular diameter 1.5 to 2.5 mm; septa 16 to 20, with 8 to 10 reaching columella. **U. Jura.:** Tex. (Malone).

A. whitneyi Wells (**42**—16). Characterized by hexameral arrangement of the 12 septa and especially by enlargement near inner ends of the secondary septa; calicular diameter 1.5 to 2.5 mm; septa 24, 6 reaching columella. **L. Cret.** (Trinity): Tex. (Glen Rose).

A. guadalupae Roemer. Calicular diameter 2.0 to 2.5 mm; septa 24, 12 reaching columella. **L. Cret.:** Tex. (Fredericksburg).

A. decaturensis Vaughan (**42**—15). Septa normally 16, of which 8 extend to columella. **M. Olig.:** Ga.; Antigua (Antigua); Cuba.

ASTREOPORA Blainville 1830

(**Astrea myriophthalma* Lamarck). Corallum massive or branching; coenenchyma porous and with upper surface spinose; septa of dissimilar proportions; columella and pali lacking. **Tert.–Recent.**

A. antiguensis Vaughan (**42**—21, 22). Corallum forming large, thick branches; calices irregular in outline, 2 to 4 mm in diameter; margins elevated about 1 mm, distant from one another 1.5 to 2.5 mm, somewhat swollen around base; septa in two to four cycles. **M. Olig.:** Ga. (Chattahoochee); Antigua (Antigua); **U. Olig.:** Panama (Culebra).

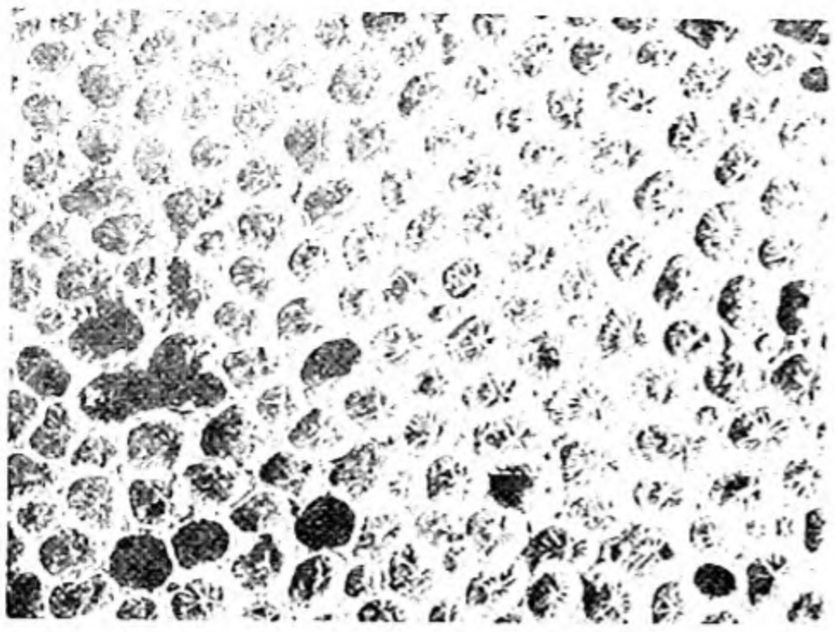
DIPLOASTREA Matthai 1914

(**Astrea heliopora* Lamarck). Corallum compound; upper surface shows imperfect corallites with synapticulate walls (simple horizontal rods, or synapticula, uniting outer ends of septa); margins of septa dentate; columella tubercular; in longitudinal section appear the interrupted corallite walls, perforate septa, and synapticula and dissepiments on septal faces. **Cret.–Recent.** (one of the most im-

PLATE 43

[Figures are x1 unless otherwise indicated.]

1–6. Discotrochus spp. 1–3. D. orbignianus [USGS, M 39]. Outline of an adult specimen (x3.5), and two views of a young corallum (x2.5). **4–6. D. californicus** (x5) [Wash Ac Sc, J 30]. Upper and lower surfaces and profile view of holotype. **7–15. Micrabacia spp.** [USGS, PP 98]. **7–10. M. hilgardi.** Side and basal views of type (x8); calicular view of type (x4); and calicular view of another specimen (x4). **11–13. M. rotatilis.** Calicular, basal, and side views of type (all about x4). **14, 15. M. cribraria.** Side view (x8) and calicular view (x4) of type. **16, 17. Goniopora reussiana** [USNM, Pr 83]. Diagram of septal formula and a group of calices (x4). **18, 19. Montlivaltia norica** [Paleontogr, Bd 37). Calicular and basal views. **20. Palastraea decussata** (x2) [USGS, PP 141]. **21. Confusastrea cowichanensis** [USGS, PP 141]. **22–25. Biothrocyathus harrisi** [JP 6]. Upper three-fourths of type (x0.5); diagram of septal plan; cross and longitudinal sections (x0.5). **26–28. Cladophyllia furcifera** [Pal Abhand, Bd 4]. Two specimens and an enlarged cross section of a calyx. **29–31. Elysastraea vancouverensis.** 29: Type specimen (x1.5) [Boston Soc N H, Pr 34]; 30, 31: Cross and longitudinal sections (x3) [USGS, PP 141]. **32, 33. Thecosmilia fenestrata** [Boston Soc N H. Pr 34]. Cross section of a calyx (x1.5) and portion of a corallum (x0.5).



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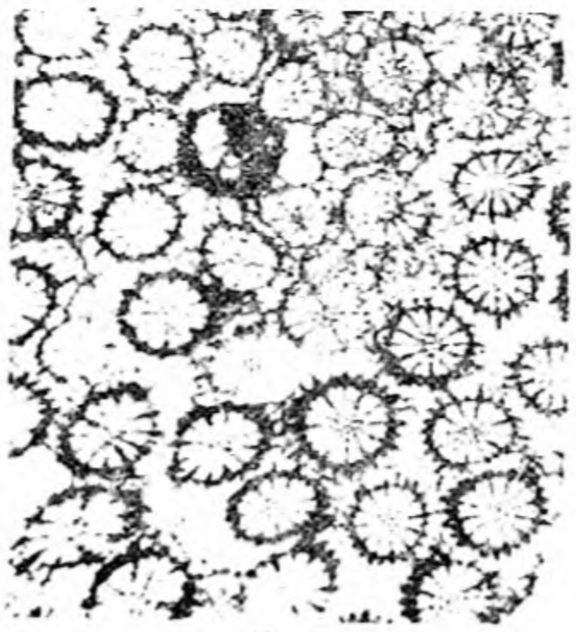

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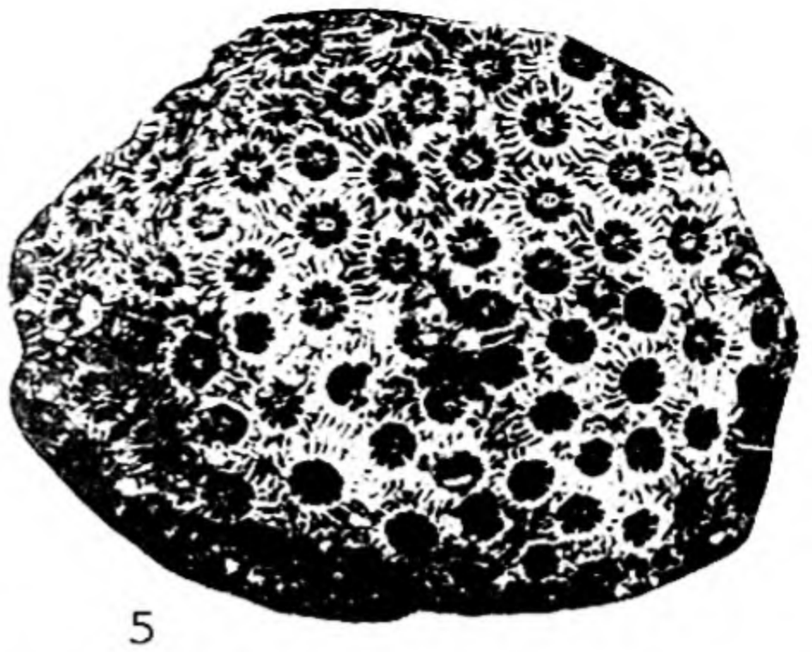

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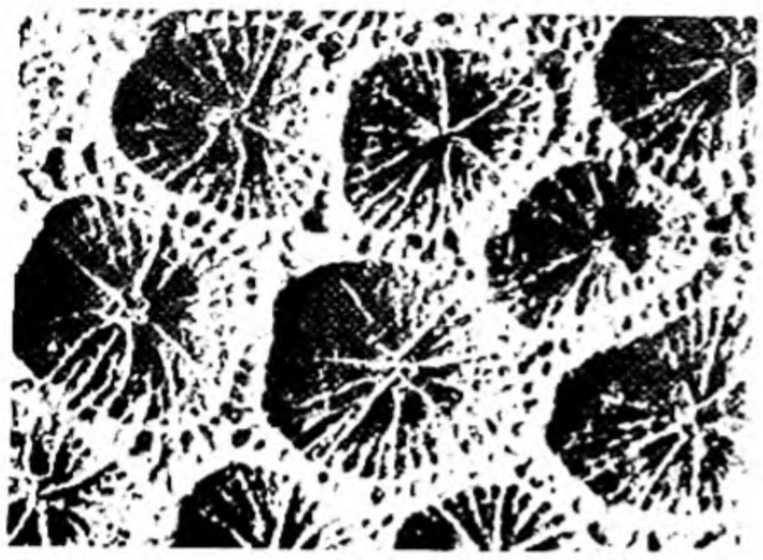

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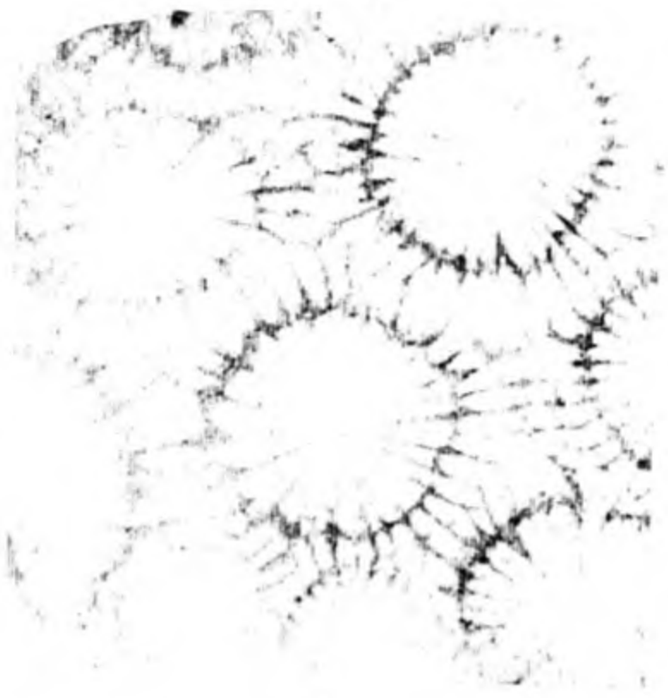

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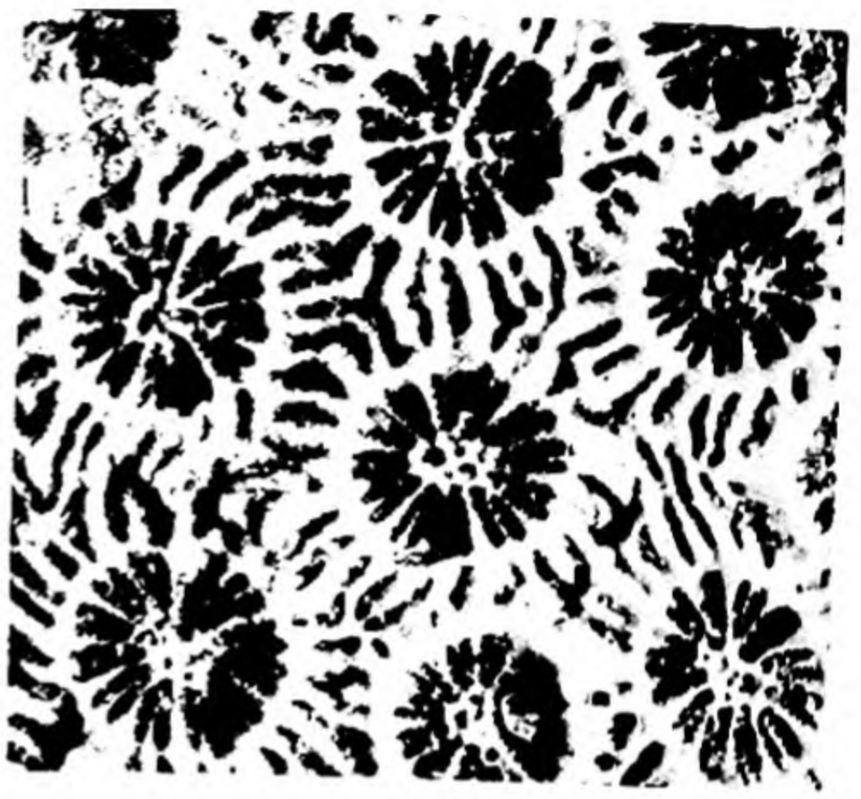

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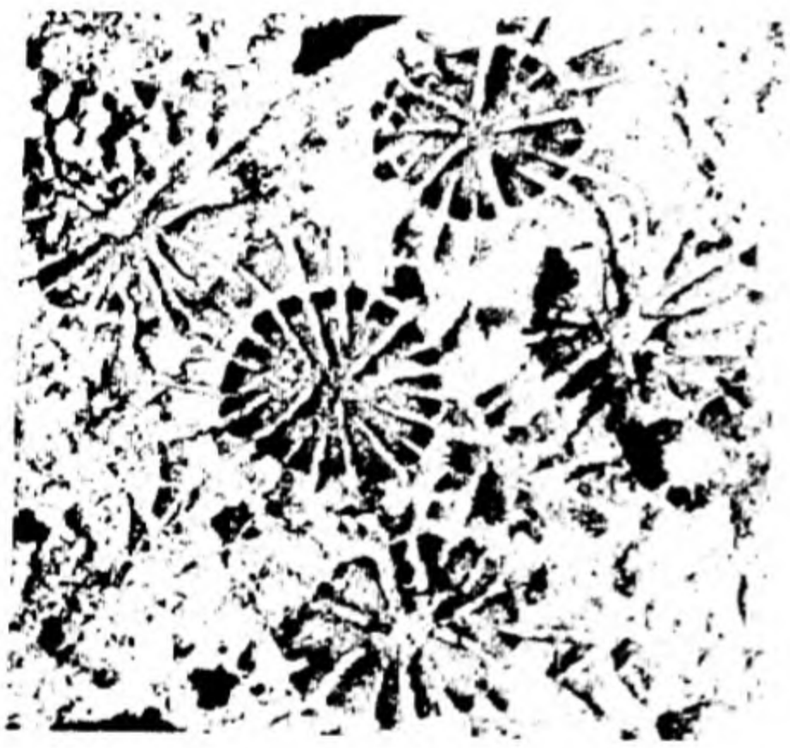

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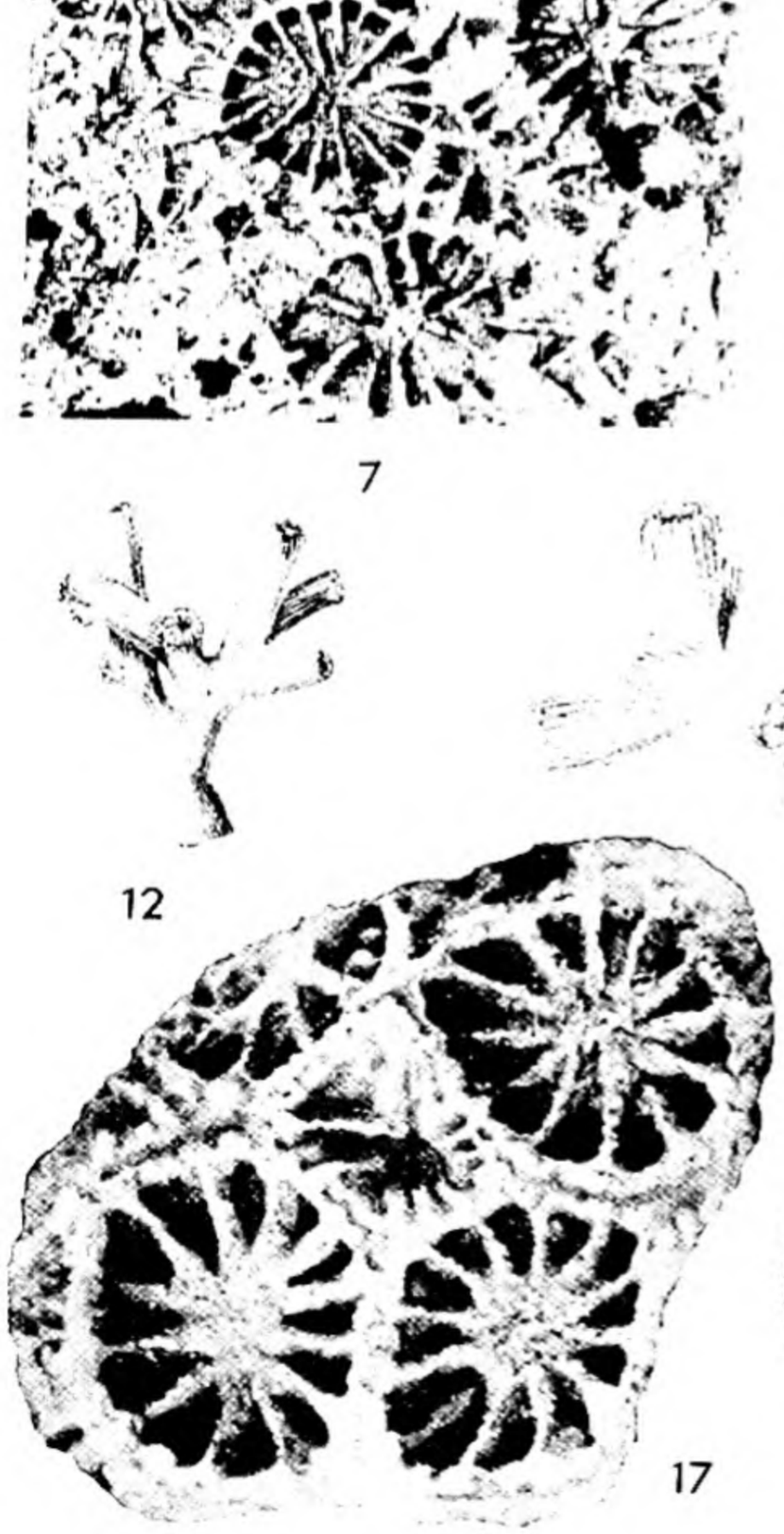

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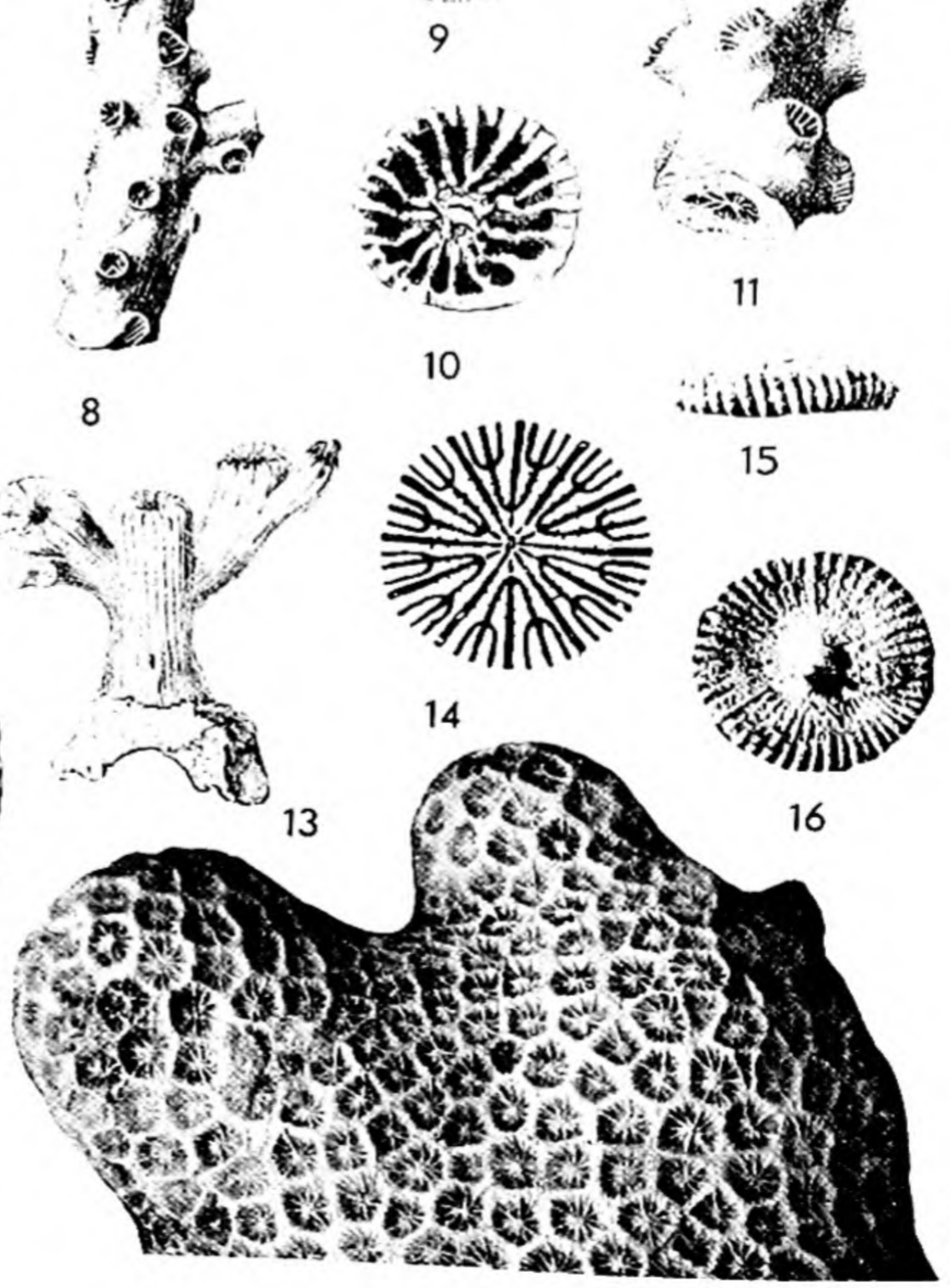

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portant genera of Oligocene corals in southeastern United States and the West Indies).

D. harrisi Wells (42—19). Differs from *D. crassolamellata* in having smaller corallites and fewer septa. **L. Cret.:** Tex. (Glen Rose).

D. crassolamellata (Duncan) (42—17, 18) Corallites long, large; septa numerous, generally characterized by great enlargement of thecal wall and by a linear appearance in the rest of their course, the higher orders being nearly linear at wall also; thecal wall delicate and indistinct; columella large. **M. Olig.:** Ga. (Chattahoochee); eastern Mexico; Antigua (Antigua); Puerto Rico (Pepino); Cuba; Panama.

THAMNASTERIA Lesauvage 1824

(**Astraea dendroidea* Lamouroux). Compound, flattened coralla; calices without walls, united by well developed, riblike septa; columella rodlike or rudimentary; a common reef coral. **Trias.–Tert.**

T. rectilamellosa Winkler (42—20). Calices 7 to 8 mm in diameter, without walls and united by ribs; 20 to 26 septa, in two cycles, those of first fusing in center of calyx to form a spongy columella. **U. Trias.** (Noric): Cal.; Europe.

DISCOTROCHUS Edwards and Haime 1848

(**D. orbignyanus*). Free, discoidal corallum with flat base and slightly arched upper surface; septa carinate, radial, the longer joining the papillose columella; costae simple. **Tert.**

***D. orbignianus** E and H (43—1–3). Base with large, unequal costae becoming indistinct near concave center; diameter 6 mm, height 1.5 mm. **Eoc.** (L. Claiborne): Ala., Miss., La., Tex.

D. californicus Wells (43—4–6). **Eoc.:** Cal. (Domengine).

MICRABACIA Edwards and Haime 1849

(**Fungia coronula* Goldfuss). Corallum single, free, lenticular, broader than high, slightly concave at base, which has circular outline; calyx with shallow depression filled by false columella; septa numerous, solid, imperforate, crenulate; intercostal spaces crossed by synapticula in concentric rows. **Cret.**

M. cribraria Stephenson (43—14, 15). Costae absent in sievelike central area of base, which includes 60% of basal diameter. **U. Cret.** (*E. ponderosa* zone); Atlantic and eastern Gulf Coastal Plain.

M. rotatilis Stephenson (43—11–13). **U. Cret.** (*E. costata* zone): Md.

M. hilgardi Stephenson (43—7–10). **U. Cret.** (*E. costata* zone): Gulf Coast.

M. americana Meek and Hayden. Costae extending to center of base; those of last cycle long (20% to 30% of basal diameter in adults); thick at terminus (edge of base); poor preservation makes identification difficult; hence reported identifications are questionable. **U. Cret.** (Pierre, Fox Hills): S. Dak., Mont., Wyo., N. Mex.

GONIOPORA Blainville 1830

(**G. pedunculata*). Colonial, massive, nodular or ramose; all structures very porous; corallites prismatic; septa 24 in number, porous, with paliform tubercles before the first cycle of six; columella usually a single tubercle. **Cret.–Recent.**

G. reussiana (Duncan). (43—16, 17). **U. Cret.:** Jamaica.

MONTLIVALTIA Lamouroux 1821

(**M. caryophyllata*). Corallum solitary; cylindrical, conical, or tubinate; septa numerous, with upper edges serrated; columella absent. **Trias.–Tert.**

M. norica Frech (43—18, 19). Conical with elliptical cross-section; septa numerous, meeting in a line. **U. Trias.** (Noric): Alaska; Ore.; Austrian Alps.

THECOSMILIA Edwards and Haime 1848

(**Lithodendron trichotomum* Goldfuss). Corallum thick, branching, bushy, with embedded calices; septa numerous, spinose or knobby; walls thick, longitudinally ribbed, with a few transverse wrinkles; columella absent or rudimentary. **U. Trias.** (N. America; Europe).

T. fenestrata (Reuss) (43—32, 33). **U. Trias.** (Noric): Alaska; B. C. (Sutton of Vancouver Island); Alps.

BLOTHROCYATHUS Wells 1932

(**B. harrisi*). Corallum simple, large, cylindrical; covered with noncostate epitheca, which is coalescent with the thin septa; other features shown in genotype illustrations. **L. Cret.**

***B. harrisi** Wells (43—22). **L. Cret.** (Trinity): Tex. (Glen Rose).

PALASTRAEA Kuhn 1936

(**Phyllocoenia grandissima* Frech). Colonial, massive; colony formation by intratentacular budding

PLATE 44

[Figures are x1 unless otherwise indicated.]

1, 2. Antiguastrea cellulosa [USNM, B 103]. Two views (x1, x4) of same specimen. **3–7. Montastrea spp. 3. M. travisensis** (x3) [JP 6]. **4. M. costata** (x3) [USNM, B 103]. **5, 6. M. roemeriana** [B Am Pal 67]. Type specimen and portion of surface enlarged (x5). **7. M. imperatoris** [USNM, B 103]. Surface (x3.3). **8–11. Acrohelia spp.** [USGS, M 39]. **8, 9. A. singleyi.** Corallum and calyx enlarged (x3.3). **10, 11. A. vicksburgensis.** Calyx enlarged (x3.3) and corallum. **12, 13. Pleurocora spp.** [Pal Abhand, Bd 4]. **12. P. coalescens. 13. P. texana. 14–16. Trochocyathus (Platycyathus) scottianus** [B Am Pal 67]. Diagram of septal plan (x5) and side and basal views of type (x4). **17, 18. Septastrea marylandica** [Md G S, Mioc]. Calices (x6.5) and portion of corallum (slightly less than x1). **19. Astrhelia palmata** [Md G S, Mioc].

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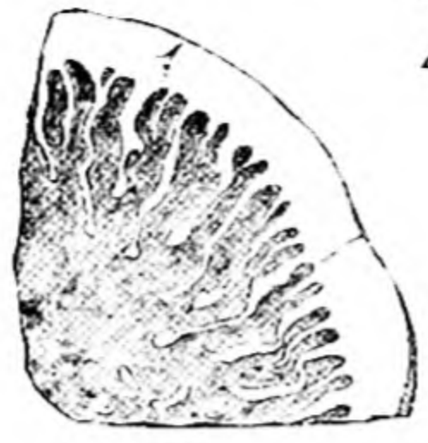
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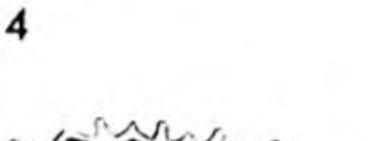
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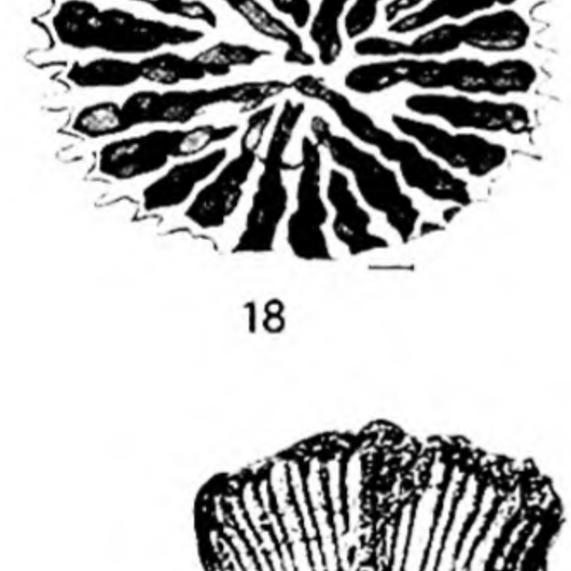
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("fission"); corallites cylindrical, often incompletely separated; with two or more centers, walls distinct, costate, with exotheca between them; septa strongly dentate; columella feeble or absent. **M.** and **U. Trias.**

P. decussata (Reuss) (**43**—20). Compact, flattened as knobby stocks, never branched; polygonal calices separated by distinct wall and united by long ribs; calices 4 to 6 mm in diameter; septa 36 when complete, in four cycles; thickening of septa corresponds to ringlike elevation surrounding calyx. **U. Trias.** (Noric): Alaska; Vancouver Island, B. C.; Cal. (Hosselkus).

ELYSASTRAEA Lambe 1865

(**E. fischeri*). Like *Palastraea*, but corallites prismatic, closely united directly by fused walls, with one or two centers. **M. Trias., L. Jura.**

E. vancouverensis (Clapp and Shimer) (**43**—29–31). **U. Trias.** (Noric): Alaska; Vancouver Island, B. C.; Cal. (Hosselkus).

CONFUSASTREA Orbigny 1849

(**C. burgundiae* Michelin). Compound; calices with indistinct walls; principal septa thickened in middle; coenenchyma crossed by some septa. **Trias., Jura.**

C. cowichanensis (Clapp and Shimer) (**43**—21). Septa 36 in four cycles, but since third and fourth are rudimentary, the number appears to be much less. **U. Trias.** (Noric): Alaska; B. C.

CLADOPHYLLIA Edwards and Haime 1851

(**Lithodendron dichotomum* Goldfuss). Branching corals with cylindrical stems multiplying by fission; calices circular with rudimentary columella or lacking one altogether; epitheca well developed. **Cret.–Recent.**

C. furcifera Roemer (**43**—26–28). Calices 4 to 6 mm in diameter; no columella; septa in three cycles; growth a regular forking structure with uniform branches; epitheca concentrically wrinkled. **L. Cret.:** Tex. (Fredericksburg).

ANTIGUASTREA Vaughan 1919

(**Astraea cellulosa* Duncan). Differs from *Montastrea* in its obscurely dentate septa, its lamellar columella, and in costae between corallites being thin, and in some instances disappearing. **Tert.**

A. cellulosa (Duncan) (44—1, 2). Calices 2 to 4 mm in diameter; wall stout. **L. Olig.:** Miss. (Byram). **M. Olig.:** Ga.; Mexico; Antigua; Puerto Rico; Cuba; **U. Olig.:** Fla. (Tampa Silex bed).

PLEUROCORA Edwards and Haime 1848

(**P. explanata*). Branching cylindrical corals with a thick, compact wall without epitheca; columella of numerous points (papillose); septa granulose, projecting above calyx; costae distinctly wavy. **Cret.**

P. coalescens Roemer (**44**—12). Slender, with calices 3 mm in diameter; septa not reaching to center, which is occupied by a spongy columella. **Fredericksburg:** Tex.

P. texana Roemer (**44**—13). **Fredericksburg:** Tex.

MONTASTREA Blainville 1830

(= ORBICELLA Dana 1846)

(**Astrea guettardi* Defrance). Massive or nodular; cylindrical corallites united by exothecally produced, confluent costal septa; columella spongy; septa with dentate margins; dissepiments numerous between septa both within and without theca. **Jura.–Recent.**

M. roemeriana (Wells) (**44**—5, 6). Characterized by large corallites, alternate septa, and well developed columella. **L. Cret.** (Fredericksburg): Tex.

M. travisensis (Wells) (**44**—3). **L. Cret.:** Tex. (Glen Rose).

M. costata (Duncan) (**44**—4). Calices 7.5 to 8.5 mm in diameter; costae highly developed. **M. Olig.:** Antigua (Antigua); Puerto Rico (Pepino); **U. Olig.:** Cuba (Anguilla); Canal Zone (Culebra).

M. imperatoris (Vaughan) (**44**—7). Distinguished by small calices, prominent costae, and six long septa, with intermediate septa shorter according to the cycle. **Olig.:** Canal Zone (Emperador).

ASTRHELIA Edwards and Haime 1849

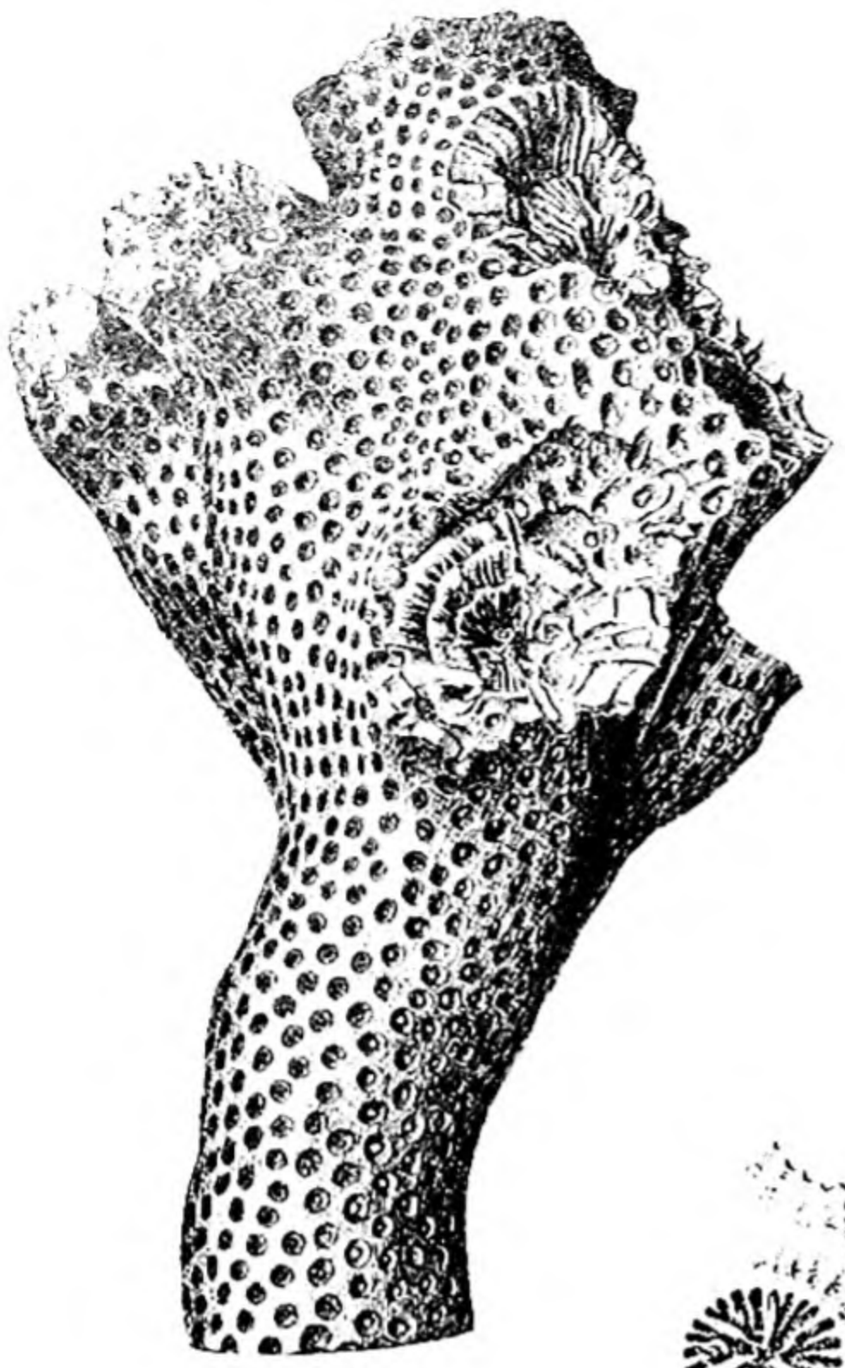
(**Madrepora palmata* Goldfuss). Calices merely excavated, rarely raised on craterlike elevations; columella spongy. **Tert.**

***A. palmata** (Goldfuss) (**44**—19). Branching, often coalescing, or in palmate expansions; calices circular, excavated; septa in three cycles, the first and second reaching the columella. **Mioc.:** Choptank and Calvert of Atlantic Coast.

PLATE 45

[Figures are x1 unless otherwise indicated.]

1–10. Trochocyathus spp. 1, 2. T. californianus [USGS, M 39]. Top and side views (x3). **3, 4. T. egerius** [B Am Pal 67]. Side view and costae enlarged (x4). **5–7. T. woolmani** [B Am Pal 67]. Side, calicular, and side views (x4). **8–10. T. zittell** [USGS, M 39]. Two views of a specimen, and part of a cross section (x3.6). **11–19. Turbinolia spp. 11–13. T. pharetra** [USGS, M 39]. Longitudinal section (x5), lateral view (x5), and calicular view (x12). **14–17. T. dickersoni** [San Diego Soc N H, Tr 7]. Side view and longitudinal section of one specimen; side view of a stout form; calyx of 14 (line at lower right indicates x1). **18, 19. T. pusillanima** [magnification and source same as preceding]. Calyx and side views. **20, 21. Platytrochus stokesi** [USGS, M 39; after Milne-Edwards and Haime]. Exterior and calyx (x3). **22, 23. Tiarasmilia casteri** [JP 6]. Calyx (x1.5) and portion of periphery enlarged (x2) showing gross structure of septa. **24–26. Platytrochus merriami** [U Cal Pub, B 9]. Two views (x5, x4) of type and base (x5) of another specimen. **27–29. Lophosmilia texana** [USGS, B 205]. Exterior views and calyx (x2). **30–32. Parasmilia spp. 30, 31. P. austinensis** [Pal Abhand, Bd 4]. Calicular and side views. **32. P. bullardi** [JP 6]. Diagram of septal plan (x2.5). **33–37. Dungulia texana** [B Am Pal 67]. Conrad's figure of type specimen, and four specimens from Texas.



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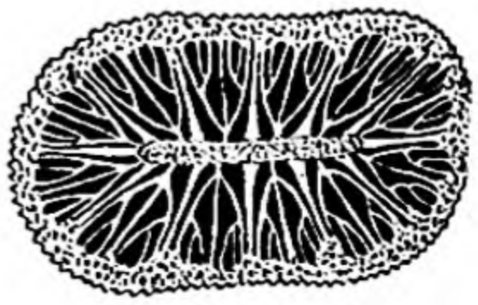

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SEPTASTREA Orbigny 1849

(**S. subramosa* = *Astraea marylandica* Conrad). Compound corals with corallites prismatic because of crowding; calices of moderate depth and with simple septa, the longer of which unite in center where they may form a pseudocolumella; no true columella or pali present. **Tert.**

***S. marylandica** (Conrad) (**44**—17, 18). Compressed stems with short, rounded branches, or large, flattened, lobate or fingerlike expansions; corallites averaging 5 to 6 mm in diameter; 12 large and 12 smaller septa occur, with occasionally a third series. **Mioc.:** Atlantic Coast (St. Marys).

ACROHELIA Vaughan 1919

(**A. limonensis*). Differs from *Oculina* solely in having a persistent axial corallite; pali or paliform teeth present on all but last cycle of septa. **Eoc., Olig.**

A. singleyi (Vaughan) (**44**—8, 9). **Eoc.** (L. Claiborne): Tex.

A. vicksburgensis (Vaughan) (**44**—10, 11). **Olig.:** Miss. (Vicksburg, Red Bluff).

TROCHOCYATHUS Edwards and Haime 1848

(**Turbinolia mitrata* Goldfuss). Corallum subturbinate; costae numerous; calyx oval, in shape of figure 8; columella fasciculate; septa forming six complete cycles, those of first three cycles nearly equal; pali rather large, granulose. **Cret., Tert.**

T. (Platycyathus) scottianus Wells (**44**—14–16). **L. Cret.** (Washita): Tex. (Weno).

T. egerius (White) (**45**—3, 4). Corallum free; septa not more than 40. **U. Cret.** (Pierre, Lewis): Western Interior of U. S. A.

T. woolmani Vaughan (**45**—5–7). Corallum attached; septa 24 to 36. **U. Cret.** (*E. cancellata* zone): Ripley and Taylor of N. J., Ga., Tex.

T. zitteli Merriam (**45**—8–10). **Paleoc.:** Cal. (Martinez).

T. californianus Vaughan (**45**—1, 2). **Eoc.:** Cal. (Domengine).

TURBINOLIA Lamarck 1816

(**T. sulcata*). Small, free, conical corals with a circular calyx; septa prolonged externally into strong costae; septa in several cycles; columella well developed. **Tert.–Recent.** (Atlantic, Gulf, and Pacific Coasts).

T. pharetra Lea (**45**—11–13). Twenty-four rounded and prominent costae with entire margins, 12 of which become larger basally; and only 6 occurring at base; a double row of pores occurs in the furrows between the costae; columella slightly projecting in form of star, with six rays, each of which fuses with a principal septum. **Eoc.** (Claiborne–Jackson): Ga., Ala., Miss., La., Tex.

T. dickersoni Nomland (**45**—14–17). **Eoc.:** Cal. (Domengine).

T. pusillanima Nomland (**45**—18, 19). **Eoc.:** Cal. (Meganos).

TIARASMILIA Wells 1932

(**T. casteri*). Corallum simple, subcylindrical or subcornute; costae prominent, corresponding to septa; septa thick, imperforate, entire on upper margins, very unequal; primary septa extend nearly to center, where they terminate in paliform swellings which more or less fill the axial space; sides of septa trabeculate; columella, dissepiments and epitheca absent; interseptal loculi open throughout. **L. Cret.**

***T. casteri** Wells (**45**—22, 23). **L. Cret.** (Trinity): Tex. (Glen Rose).

PLATYTROCHUS Edwards and Haime 1848

(**Turbinolia stokesi* Lea). Simple, cuneiform corals with a columella formed of the fused edges of the septa; externally septa are represented by thick costae, while within outer wall their margins are carinated. **Tert.**

***P. stokesi** (Lea) (**45**—20, 21). Small, with base drawn out into a wedge nearly as wide as coral above; septa and costae 24, of which 9 on middle of each broad face converge and unite downward, while those on each side become broader; surface rough with granules; columella papillose. **Eoc.** (Claiborne): S. C., Ala., Miss., Tex.

P. merriami (Nomland) (= **Flabellum? merriami**) (**45**—24–26). **Eoc.:** Cal. (Capay).

LOPHOSMILIA Edwards and Haime 1848

(**Caryophyllia cenomana* Michelin). Corallum simple, subturbinate, adherent; calyx almost circular; columella lamellar, small; septa unequal, their apical margin highly arched and their sides granular; costae simple. **Cret., Tert.**

L. texana (Vaughan) (**45**—27–29). Characterized by costae alternating large and small. **U. Cret.:** Tex. (Buda).

PARASMILIA Edwards and Haime 1848

(**Madrepora centralis* Mantell). Cylindrical or conical, simple corals with a scar of attachment at

PLATE 46

[Figures are x1 and after Vaughan [USGS, M 39] unless otherwise indicated.]

1–3. Haimesiastraea conferta. Portion of corallum, longitudinal section (x8.3), and several calices (x6.6). **4–8. Flabellum spp. 4. F. cuneiforme** (x1.6). **5. F. lerchi.** Calicular view (x2.3). **6, 7. F. redmondianum.** Cross section (x2) and exterior (x1.5). **8. F. cuneiforme pachyphyllum. 9. Axosmilia craginiana** [B Am Pal 67]. Type. **10–19. Balanophyllia spp. 10, 11. B. irrorata.** Exterior of a typical specimen and cross section (x2). **12, 13. B. desmophyllum.** Outline (x0.8) and complete specimen (x2.5). **14–16. B. elaborata.** Outline (x0.8), cross section (x2), and exterior (x2.5). **17–19. B. variabilis** [U Cal Pub, B 9]. Type (x1.3), cross section (x2), and exterior of short specimen (x2). **20, 21. Endopachys maclurii.** Side and calicular views of Milne-Edwards and Haime's figure.

base; calyx circular, with granular septa and a spongy columella; epitheca absent or rudimentary, and costae strong. **Cret.**

P. austinensis Roemer (**45**—30, 31). Top-shaped coral attached by a broad base, above which it is contracted; strong equal costae; calyx slightly compressed with septa in four cycles. **Fredericksburg:** Tex. (Edwards).

P. bullardi Wells (**45**—32). **L. Cret.** (Trinity): Tex. (Glen Rose).

DUNGULIA Oppenheim 1930

(**Coelosmilia milneri* Gregory). Solitary, trochoid, usually fixed; wall solid, costate, lacking epitheca; septa in three or four cycles, with nondentate margins; columella very feeble or absent; endotheca poorly developed. **U. Jura.–Recent?.**

D. texana (Conrad) (**45**—33–37). Septa in four complete cycles, thin, granulate, those of first two cycles being equal and thicker than the rest, extending almost to center of corallum; no columella; 48 nearly equal costae, distinct to base. **L. Cret.:** Tex. (Fredericksburg); Chihuahua, Mex.

HAIMESIASTRAEA Vaughan 1900

(**H. conferta*). Colony massive or ramous; corallites in central portion of colony united directly by their walls, costae, or exotheca; septa in 3 cycles, 6 systems; 12 reach columellar space; columella false, formed by fusion of internal margins of first two cycles of septa; granulate coenenchyma in younger portion; costae well developed. **L. Eoc.** (Md., La.; Peru, S. A.).

***H. conferta** Vaughan (**46**—1–3). **L. Eoc.:** Ala.

FLABELLUM Lesson 1831

(**F. favonium*). Simple, wedge-shaped, compressed, free or attached coralla, with numerous septa and a compressed columella; a wrinkled epitheca with spinose processes may occur. **Cret.** (Pacific). **Tert.–Recent** (Atlantic, Gulf, and Pacific Coasts).

F. cuneiforme Lonsdale (**46**—4). Base with short prolongation of attachment; form a compressed wedge marked by strong costae which are largest in middle; first three cycles of septa form columella by fusion of their inner margins. **M.** and **U. Eoc.:** S. C., Ga. to Tex., Ark. (Several distinct varieties are recognized; var. **lerchi** Vaughan (**46**—5) and var. **pachyphyllum** Gabb and Horn (**46**—8).)

F. redmondianum Gabb (**46**—6, 7). **Paleoc.:** Cal. (Martinez).

AXOSMILIA Edwards and Haime 1848

(**Caryophyllia extinctorium* Michelin). Corallum simple, free, turbinate; calyx circular; fossula large and deep; columella styliform, strongly compressed; septa numerous, larger ones cemented to columella; well developed epitheca, which is folded or wrinkled. **Cret.**

A. craginiana (Wells) (**46**—9). Septa 85 to 100, regularly alternating in size, the larger and thicker ones twice as long as rest, and extending three-quarters distance to axis of deep, empty fossette; columella a thick lamella, attached to one large septum; epitheca wrinkled by growth lines, sometimes lost through weathering. **Fredericksburg:** Tex.

BALANOPHYLLIA Wood 1844

(= EUPSAMMIA Edwards and Haime 1848)

(**B. calyculus*). Simple conical corals attached by base; septa very numerous, closely crowded and partly fused together; columella spongy; epitheca often present, structure porous. **Eoc.–Recent.**

B. desmophyllum Edwards and Haime (**46**—12, 13). Basal portions cylindrical, becoming conical upwards; section elongate, elliptical with rather deep calyx; septa thin, costae fine; epitheca rudimentary or absent. **Eoc.** (Chickasaw and Claiborne): Md., Ala., Miss., Tex.

B. irrorata (Conrad) (**46**—10, 11). Slender cylindroconical, curved; cross-section elliptical; epitheca on basal portion. **Eoc.** (Claiborne, Jackson): Ala., La., Miss., and varieties in Tex.

B. elaborata (Conrad) (**46**—14–16). Conical with elliptical section; finely perforated costae trifurcating upward; no epitheca; spongy columella, and thin anastomosing septa; walls spongy. **Eoc.** (Chickasaw): Md., Va., Ala.

B. variabilis Nomland (**46**—17–19). **Eoc.:** Cal. (Capay, Domengine).

ENDOPACHYS Lonsdale 1845

(**Turbinolia maclurii* Lea). Corals with general form of *Flabellum*, but with porous wall structure and septal arrangement like *Balanophyllia*; lateral wings often developed; a compressed spongy columella present. **Tert.**

***E. maclurii** (Lea) (**46**—20, 21). Cuneate, with subparallel margins, sides and ends rounded; lateral wings well developed; columella narrow and elongate in long axis of corallum; very vesiculate; numerous varieties recognized. **Eoc.** (Claiborne, Jackson): Ga., Ala., Miss., La., Tex.

CHAPTER V

PHYLUM ECHINODERMA[1,2]

The echinoderm animal is incased in a spheroidal or discoidal calcareous test, or in an ellipsoidal or star-shaped leathery integument studded with calcareous plates. One large group, mostly extinct now, had the test fastened to the bottom by a stem consisting of numerous thin plates (*columnals*). Most of these also had arms surrounding the mouth and extending the food grooves outward from the oral surface of the test. The second large group consists of vagrant benthonic individuals, and is well represented in modern marine faunas.

Echinoderms have left a fairly good fossil record and, if they are preserved at all, they are quite likely to occur in great abundance. Complete and well preserved specimens are not so common as mashed and distorted and partly disintegrated tests. Isolated plates, which are commonest of all, are scattered through marine formations from the Cambrian to Recent time. These fragments have assumed considerable importance in recent years because of their use by petroleum paleontologists and will be discussed at some length under Crinoidea.

Many echinoderms are excellent index fossils, and preserved remains may be expected in strata from Cambrian to Recent age.

The phylum is usually divided as follows (extinct divisions are indicated by *):

SUBPHYLUM PELMATOZOA (stemmed or attached)

- Class ***Cystoidea**
- Class ***Edrioasteroidea**
- Class ***Blastoidea**
- Class **Crinoidea**

SUBPHYLUM ELEUTHEROZOA (free and vagrant)

- Class **Stelleroidea**
  - Subclass **Asteroidea**
  - Subclass ***Auluroidea**
  - Subclass **Ophiuroidea**
- Class **Echinoidea**
- Class **Holothuroidea**

SUBPHYLUM PELMATOZO

CLASS CYSTOIDEA[3]

The cystoids are extinct marine invertebrates which flourished only during Paleozoic time. Most of them lived during the Ordovician or Silurian, but some Cambrian and Devonian forms are also known. They were mostly stemmed organisms with a calyx like that of the crinoids, but with imperfect arms. The calyx, which varies in form, is composed of polygonal plates united by close sutures. The plates vary in number in different species, from 13 to several hundred, and only exceptionally exhibit regular arrangement. A radial arrangement, like that of the crinoids, occurs rarely, and the side plates pass insensibly into those of the ventral or upper side. In the center of the dorsal or under side, however, there is a regular series of *basal plates* which rest on the *stem* or *column*.

The mouth is a central or nearly central aperture on the ventral side and is sometimes covered with small plates. From it radiate two or more simple or branching *ambulacral grooves* or *ambulacra*. These *food grooves* were also frequently roofed over with

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[1] We take pleasure in acknowledging the valuable assistance of the following: Drs. A. H. Clark, L. M. Cline, C. Wythe Cooke, Edwin Kirk, L. R. Laudon, R. C. Moore, and L. W. Stephenson. More specific acknowledgments are made later.

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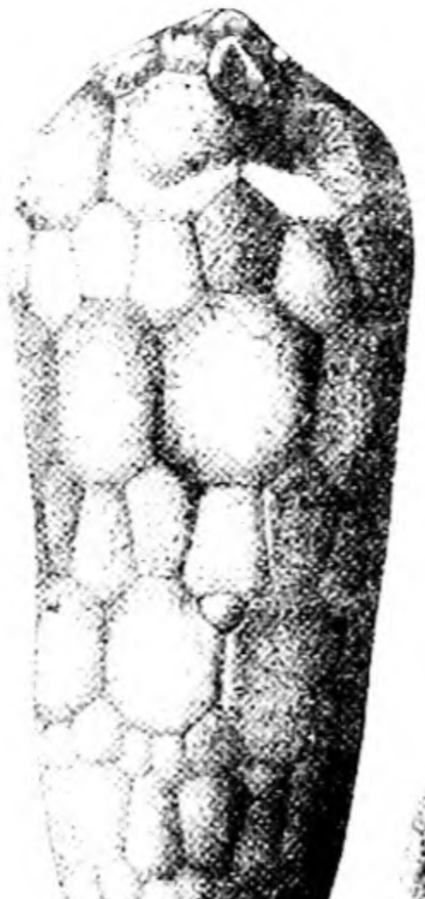

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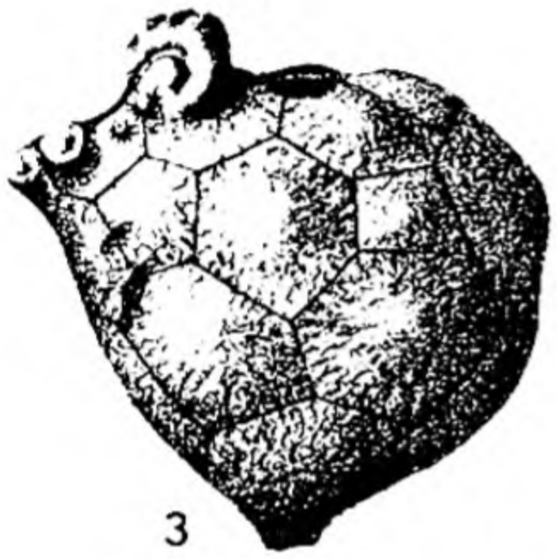

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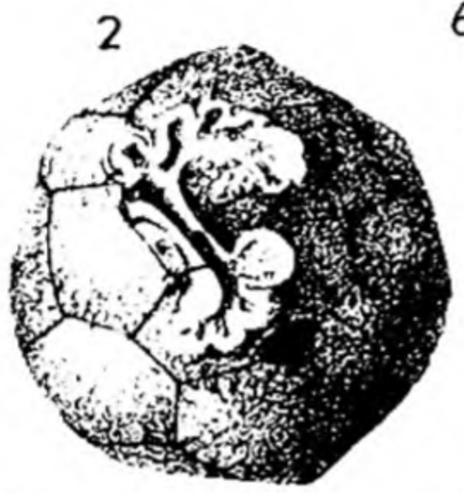

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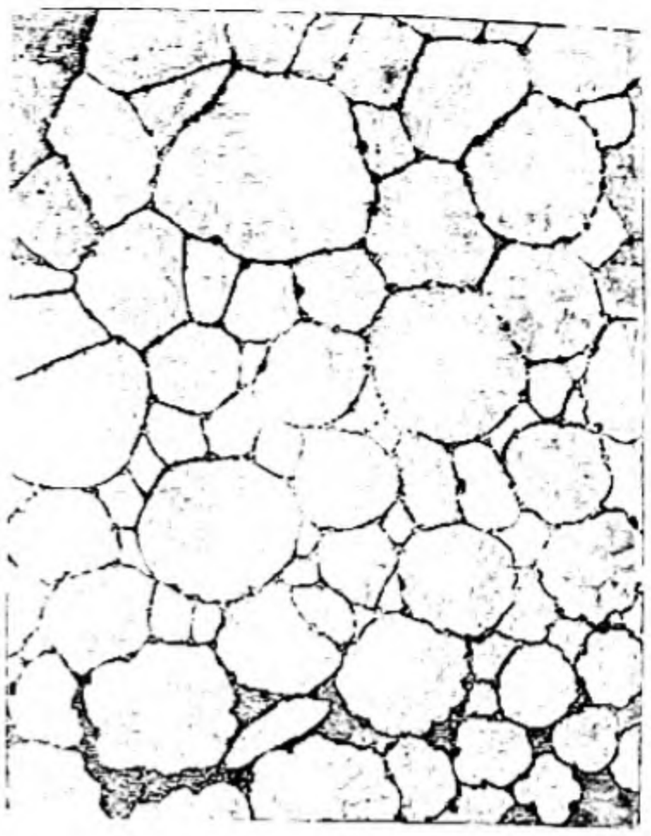

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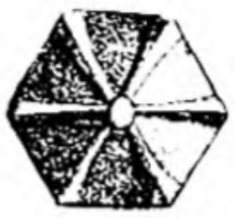

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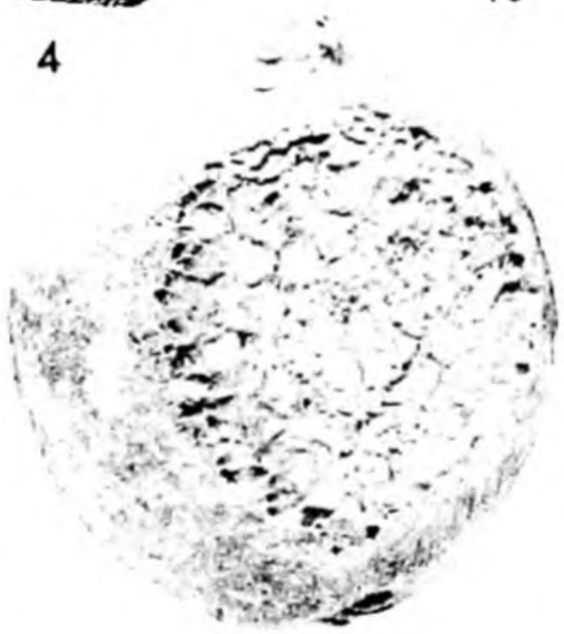

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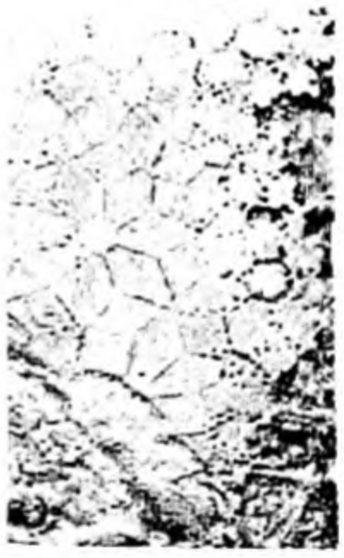

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plates. The arms, feebly developed in the cystoids, and often even lacking altogether, arise from the distal end of the ambulacra. If present, they are unbranched, consisting of a single (*uniserial*) or double (*biserial*) row of plates, and possess a ventral groove protected by *covering plates*. Just beneath the mouth is often a small, porous *madreporite*. The anal opening, more eccentrically placed than the mouth, is frequently closed by a *valvular pyramid*.

The calyx plates in most cystoids are perforated by pores or fissures. These are often arranged to form lozenge-shaped or rhombic figures (the *pore-rhombs*), which are disposed one-half on each of two adjoining plates, whereas the line of suture between the plates forms either the longer or shorter diagonal of the rhomb (**47**—16–18). The pores on opposite sides of the rhombs are united by perfectly closed straight ducts which pass horizontally through the plates, vertically across the line of suture, and produce a transversely striated appearance (e.g. *Caryocrinites*, **47**—22, 23). These striate rhombs usually are not visible except on weathered specimens. They may be present on all plates or on only a few. In *Callocystites* (**48**—1–3) and other related genera, the pore-rhombs are reduced to comblike rhombs (the *pectinate rhombs*), which are few in number, lying on contiguous plates as do the pore-rhombs, but the two parts are of different form or size, or one of them may become obsolescent. These structures probably had a respiratory function.

Cystoids are not commonly well preserved nor are they of common occurrence; hence they are relatively unimportant as index fossils. They range from Cambrian to Permian.

Order Amphoridea. No radial symmetry in food grooves or calyx plates. **Camb., Ord.**

MEGACYSTITES Hall 1865

(= HOLOCYSTITES Hall 1864)

(**Caryocystites cylindricus*). Calyx elongate to subcylindrical, short stemmed or stemless, composed of large plates in quite regularly alternating series, pierced by pores which are united in pairs; mouth nearly central; minute arms or spines spring from ends of ambulacral grooves. **Sil.**

***M. cylindricus** (Hall) (**47**—1). **Niagaran:** Wis. (Racine).

M. alternatus (Hall) (**47**—2). Calyx composed of 12 series of plates alternating in size; surface strongly granulose. **Niagaran:** Ohio (Cedarville), Wis. (Racine).

EOCYSTITES Billings 1868

(**E. primaevus*). Calyx plates numerous, varying in size, form, and ornamentation. **Camb.**

E.? longidactylus Walcott (**47**—7, 8, 27). Calyx plates without apparent order, and varying in form, size, and surface characteristics on same specimen; plates smooth to somewhat radiately sculptured, their margins indented, probably indicating pores; arms several, long, slender, biserial, with one or two (?) pinnulelike plates arranged upon the one side of each arm plate; stem of numerous irregular small plates. **L. Camb.** (Pioche): Utah, Nev.

***E. primaevus** Billings (**47**—28, 29). Known only from calyx plates, which are polygonal, with strong ridges radiating from elevated center. **M. Camb.:** N. B.

MALOCYSTITES Billings 1857

(**M. murchisoni*). Calyx globular, composed of 40 or 50 thick and solid plates; ambulacra in two groups, varying in number, connected by a short groove; pores and pore-rhombs absent. **Ord.**

***M. murchisoni** Billings (**47**—12, 13). Plates covered with small tubercles; ambulacra in two groups of four each, connected by a short groove; usual diameter 25 mm. **Chazyan:** Que.

CANADOCYSTIS Jaekel 1900

(= SIGMACYSTIS Hudson 1911)

(**Malocystites barrandi* Billings). Differs from *Malocystites* in having ambulacra much reduced in length so that they appear to be only two, connected by a groove at mouth, the whole appearing like the letter S. **Ord.**

***C. barrandi** (Billings) (**47**—5, 6). Plates smooth or very minutely granulated. **Chazyan:** Que.

C. emmonsi (Hudson) (**47**—3, 4). Smaller than preceding and with globular calyx irregularly angular. **Chazyan:** N. Y.

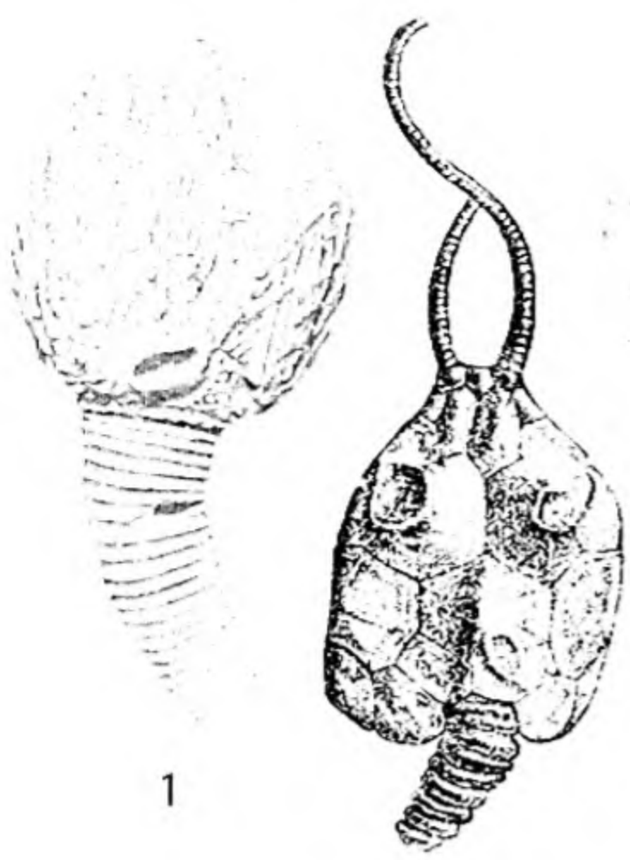
AMYGDALOCYSTITES Billings 1854

(**A. florealis*). Calyx flattened and elongate; plates without pores, numerous, irregularly arranged;

PLATE 47

[Figures are x1 and after Billings [CGS, COR, d 3] unless otherwise indicated.]

1, 2. Megacystites spp. [N Y St Cab, An Rp 20]. **1. M. cylindricus. 2. M. alternatus. 3–6. Canadocystis** spp. **3, 4. C. emmonsi** [N Y St Mus, B 80]. Side and summit views of type (x4). **5, 6. C. barrandi.** Anterior and left side views. **7, 8. Eocystites? longidactylus.** [USGS, B 30]. Outline figure of a specimen with the plates crushed in on each other; enlargement of a group of plates from a large specimen. **9–11. Amygdalocystites florealis.** Enlarged plate; view of left side (m = mouth); posterior view. **12, 13. Malocystites murchisoni.** Views of right and left side (a = ambulacral orifice; m = mouth). **14, 15. Wellerocystis kimmswickensis** [Ohio J Sc 2]. **16–19. Palaeocystites tenuiradiatus.** 16: Exterior of several plates; 17, 18: Edge of plate showing entrances of pores and inside of several plates showing opening of pores in suture; 19: A plate [Okla G S, B 55]. **20, 21. Echinosphaerites aurantium** [Va G S, B 2A]. A complete specimen and some plates enlarged (x2). **22, 23. Caryocrinites ornatus** [Pal N Y 3]. Two views of a well preserved specimen. **24–26. Comarocystites punctatus.** 24: Anterior view of a large specimen with one arm and pinnules attached (o = mouth); 25: Valvular apparatus of mouth enlarged; 26: A plate enlarged. **27–29. Eocystites** spp. (also see figs. 7, 8). **27. E.? longidactylus** [USGS, B 30]. A plate enlarged (x5). **28, 29. E. primaevus.** Plate [Dawson: Acadian Geol]; a plate enlarged (x4) [USGS, B 10]. **30–35. Pseudocrinites** spp. [SMC 47]. **30–32. P. gordoni.** An elongate specimen and two views of holotype. **33–35. P. clarki.** Three views of holotype.



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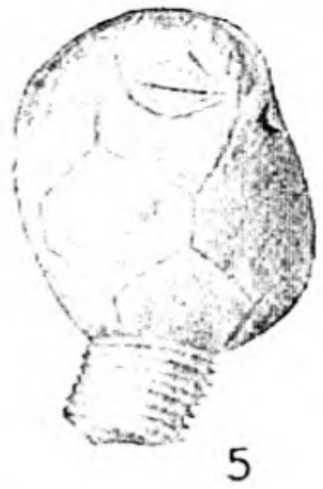

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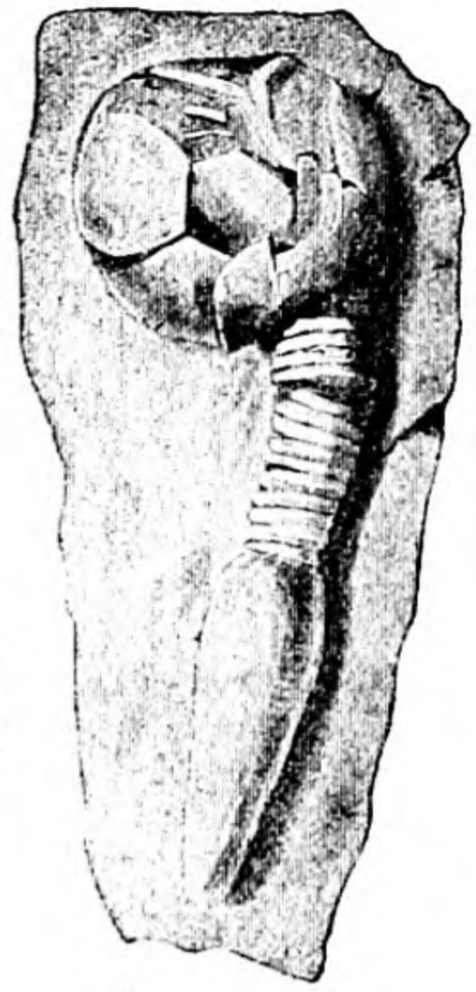

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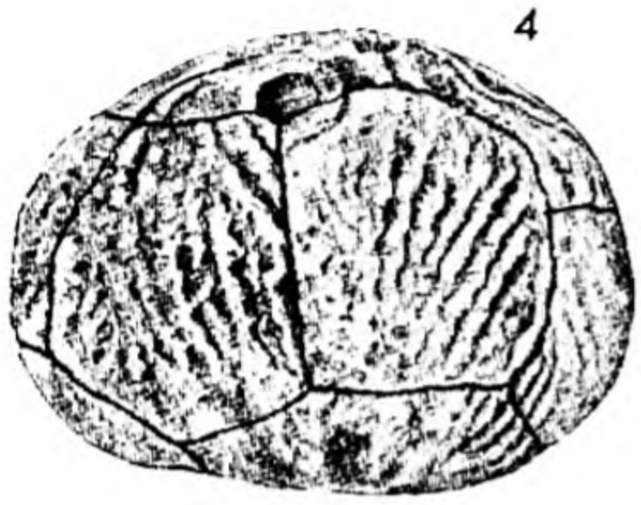

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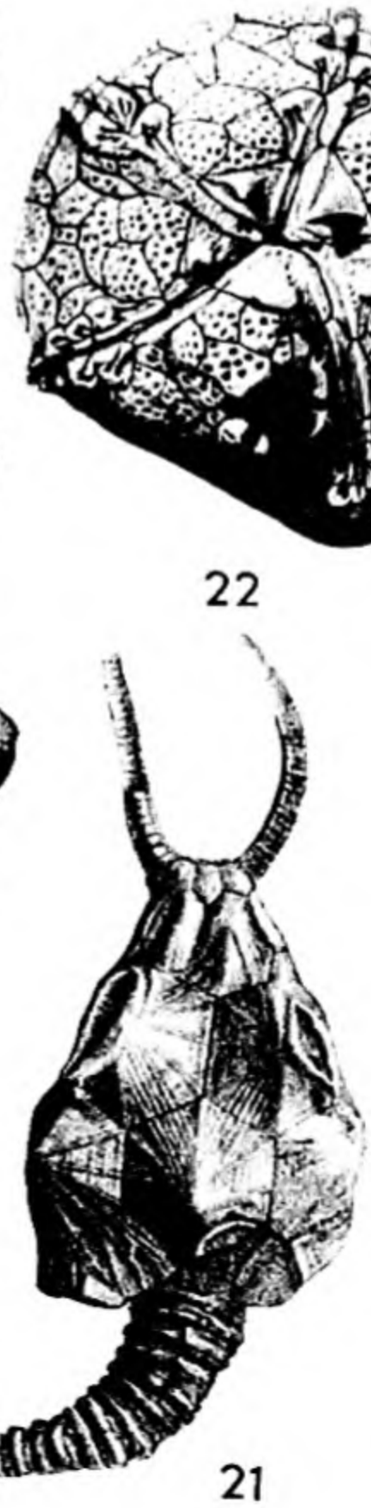

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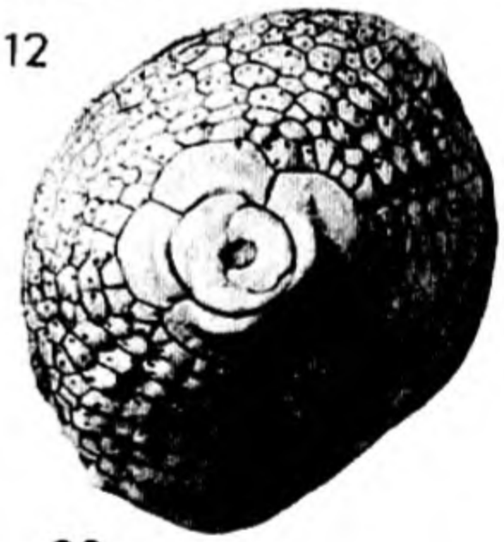

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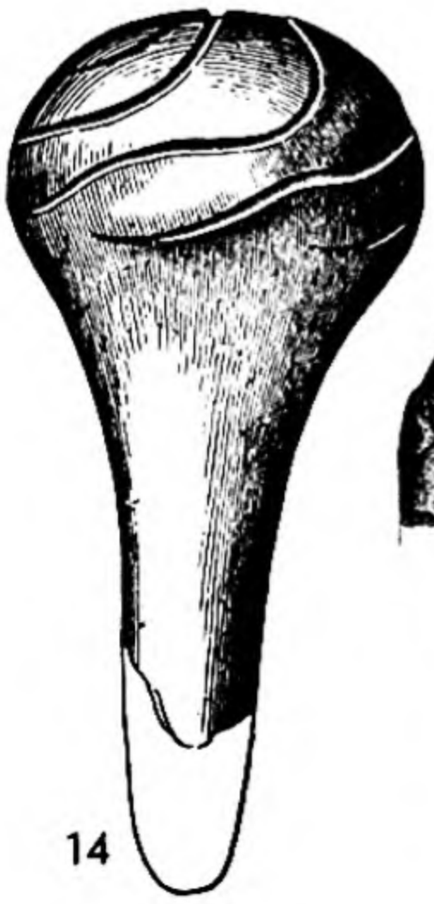

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ambulacra two, unbranched, bordered by brachioles, and passing from a subcentral mouth over the calyx; column round and smooth. **Ord.**

***A. florealis** Billings (47—9–11). Each calyx plate with low ridges radiating from a centrally placed tubercle to the angles; posterior ambulacrum much the longer; calyx about 38 mm long. **M. Ord.:** Ont. (Hull); Ky. (Curdsville).

WELLEROCYSTIS Foerste 1920

(**W. kimmswickensis*). Like *Amygdalocystites*, but there are three instead of two ambulacra, with the one farthest from anus branching; anal opening within area inclosed by concavely curved side of undivided ambulacrum; also ovoid in form and lacking radiate ribbing on thecal plates. **M. Ord.**

***W. kimmswickensis** Foerste (47—14, 15). **Kimmswick:** Mo.

COMAROCYSTITES Billings 1854

(**C. punctatus*). Calyx ovoid or pyriform, with 3 basal plates above which are 8 to 11 cycles of mostly hexagonal plates arranged in irregular order; ambulacrum at apex, short, straight, unbranched; from each end rises a pair of uniserial arms which bear long, cylindrical pinnules; anal area near apex, composed of a pyramid of 5 pieces and an outer circle of about 5 plates; column round and smooth, its plates very thin. **Ord.**

***C. punctatus** Billings (47—24–26). Calyx about 38 mm long, 25 mm in diameter; each plate has deep impression occupying nearly its entire area and usually has thin, erect lamellae perpendicular to sides of plates; these lamellae may be crossed by others which are parallel to sides of plates. **Trenton:** Que., Ont. (Hull); Mich.

Order Rhombifera. Radial symmetry in food grooves and sometimes in calyx plates; food grooves borne on brachioles; calyx plates more or less folded and provided with rhombs. **Ord., Sil.**

ECHINOSPHAERITES Wahlenberg 1821

(**Echinus aurantium* Gyllenhal). Globose, nonpedunculate, composed of numerous (about 100) irregularly arranged plates, all of which bear pore-rhombs; mouth central, ambulacral grooves short, arms unknown; anal opening near mouth, protected by valvular pyramid. **Ord.**

***E. aurantium** (Gyllenhal) (47—20, 21). **M. Ord.:** Pa. and Va. (Chambersburg), W. Va., Tenn., Mo.; Estonia.

PALAEOCYSTITES Billings 1858

(**Actinocrinus tenuiradiatus* Hall). Calyx ovoid or pyriform; plates bearing pores which penetrate margins and extend to center but do not open on exterior surface; this gives edges of plates, if viewed from within, a notched appearance; ducts pass vertically across sutures. **Ord.**

***P. tenuiradiatus** (Hall) (47—16–19). Length about 50 mm; plates somewhat hexagonal, depressed conical; if slightly worn, plates are covered with deep striae, the cut edges of the pore ducts. **Chazyan:** Que.; N. Y., Okla. (Simpson).

CARYOCRINITES Say 1825

(= CARYOCRINUS of authors)

(**C. ornatus*). Calyx ovoid or subglobose; base dicyclic, i.e. lowest plates (infrabasals) are four, unequal, followed by a second row of six basals which alternate in position with those of preceding and succeeding cycles; third cycle consists of eight plates of which six are radials, two interradials; ventral surface formed of six or more small pieces; all of the plates of the calyx bear pore-rhombs; mouth and ambulacral grooves situated below ventral plates or tegmen; anal opening protected by valvular pyramid and situated on outer margin of ventral surface; arms 6 to 13, feebly developed, situated on ventral margin; stem long, composed of cylindrical joints. **Sil.**

***C. ornatus** Say (47—22, 23). Greatest diameter of calyx usually below middle; summit slightly convex, with arms as much as 50 mm long; upper margins of radial and interradial plates indented for arm plates; pores represented on plate exterior by single or double rows of tubercles radiating from center of plate to angles; between these are many rows of smaller tubercles parallel to sides of plates. **Niagaran:** Ont.; N. Y. (Rochester), Ind. (Osgood).

PSEUDOCRINITES Pearce 1843

(**P. bifasciatus*). Calyx laterally compressed, circular to subquadrate in section, composed of four cycles (basal cycle of four plates, the succeeding of five, four, and six respectively) and a very small plate above these; anal area laterally situated, composed of pyramid of seven pieces and surrounded by an incomplete circle of six to eight pieces; pectinate rhombs three, one basal and two upper; ambulacra two to four extending along narrow periphery of calyx and usually to column, and beset with biserial jointed pinnules. **Sil., Dev.**

PLATE 48

[Figures are x1 and after Schuchert [SMC 47] unless otherwise indicated.]

1–3. Callocystites spp. **1, 2. C. jewetti.** Antanal and anal views. **3. C. canadensis.** Side view with anal pyramid to right. **4. Pleurocystites squamosus** [CGS, COR, d 3] (See fig. 16, this plate). Dorsal view. **5, 6. Lepocrinites gebhardi** [Pal N Y 3]. View of left side of a specimen, and a complete but crushed specimen. **7, 8. Sphaerocystites multifasciatus.** Anal and top views (x2). **9–12. Coelocystis subglobosus** [Ohio J Sc 21]. Anal and top views of one specimen; basal and side views of another. **13, 14. Gomphocystites glans** [N Y St Cab, An Rp 20]. Two views of an almost complete specimen. **15. Hallicystis imago** [N Y St Cab, An Rp 20]. Lateral view. **16. Pleurocystites squamosus** [CGS, COR, d 3] (See fig. 4, this plate). Ventral view. **17–19. Jaekelocystis hartleyi.** 17: Two plates (x8) with discrete pectinirhombs. 18: Oral view (x8); 19: Holotype, and opening to right (x2). **20, 21. Pleurocystites filitextus** [CGS, COR, d 3]. Ventral and dorsal views. **22–24. Eumorphocystis multiporata** (x1.5) [JP 14]. Summit, basal, and posterior views.

P. gordoni Schuchert (**47**—30-32). Ambulacra extending to column, with about 80 pinnules. **L. Dev.:** W. Va. (Keyser).

P. clarki Schuchert (**47**—33-35). Ambulacra extending to column, with about 44 pinnules. **L. Dev.** W. Va. (Keyser).

CALLOCYSTITES Hall 1852

(**C. jewetti*). Calyx ovoid, composed of 25 plates arranged in four cycles with partial telescoping of second and third cycles; pectinate rhombs three, one basal and two upper; mouth slitlike and forming center of radiation for ambulacra, which number five, are slightly excavated, and sometimes bifurcating; stem well developed, tapering distally to a point. **Sil.**

***C. jewetti** Hall (**48**—1, 2). Each rhomb surrounded by a high wall; anal opening between second and third cycles of plates, excavated in two plates of former and one of latter; ambulacra simple, or more commonly one or more branching once; plates ornamented with polygonal depressions, a more or less defined border and granulose surface. **Rochester:** Ont.; N. Y.

C. canadensis (Billings) (**48**—3). The halves of each pectinate rhomb adjoined closely and not separated by a high wall as in preceding. **Rochester:** Ont.; N. Y.

HALLICYSTIS Jaekel 1899

(**Apiocystites imago* Hall). Calyx regularly ovoid, elongate, or slightly compressed; deltoid plates five. **Sil.**

***H. imago** (Hall) (**48**—15). **Niagaran:** Wis. and Ill. (Racine), Ohio (Cedarville).

LEPOCRINITES Conrad 1840

(**L. gebhardi*). Calyx ovoid or pyriform, composed of 20 plates arranged in circular rows of 4 cycles; first or basal cycle consisting of 4 plates; second, third, and fourth of 5 plates each; twentieth plate very small, situated on top of fourth cycle or between it and third; anal area small, placed between second and third cycles, consisting of pyramid of six pieces surrounded by complete circle of many small pieces; pectinate rhombs three, one basal and two upper; ambulacra four, undivided, usually not longer than half calyx length; column tapering, composed of an upper portion of about 15 plates and a thick distal part of many anchylosed plates coated by a nodose calcareous layer. **Sil., Dev.**

***L. gebhardi** Conrad (**49**—5, 6). Column composed of two distinct parts; surface of calyx plates granular. **L. Dev.:** Coeymans of N. Y., Md.

SPHAEROCYSTITES Hall 1858

(**S. multifasciatus*). Calyx spheroidal, wider than high, with 18 plates in 4 cycles and partial telescoping of second and third cycles; ambulacra four, bifurcating many times; pinnules widely separated, slender, short, club-shaped; pectinate rhombs three, one basal and two upper, with the halves separated by an interval; anal area composed of pyramid of 6 to 8 pieces and an outer circle of 10 to 14 pieces; column stout, terminating basally in a few "roots." **Sil., Dev.**

***S. multifasciatus** Hall (**48**—7, 8). Base of calyx more or less excavated; branches of ambulacra varying from 14 to 27, obscuring suture lines. **U. Sil.** (Keyser): Md., W. Va.

COELOCYSTIS Schuchert 1903

(**Hemicosmites subglobosus* Hall). Characterized by a depressed globular theca with deeply invaginated base and composed of 24 plates; pectinirhombs small, discrete, with few dichopores. **Sil.**

***C. subglobosus** (Hall) (**48**—9-12). **Niagaran:** Ohio (Cedarville), Wis. and Ill. (Racine).

JAEKELOCYSTIS Schuchert 1903

(**J. hartleyi*). Calyx pyriform or globular, composed of 19 plates arranged in circular series; first or basal series consisting of 4 plates, second of 5, third of 4, and fourth of 5; nineteenth plate situated on last row; anal area protruding, consisting of pyramid of six pieces; pectinate rhombs three, one basal and two upper; ambulacra four, rarely three or five, depressed, continued to or nearly to column. **Sil., Dev.**

***J. hartleyi** Schuchert (**48**—17-19). Calyx strongly sculptured. **U. Sil.:** W. Va. (Keyser).

PLEUROCYSTITES Billings 1854

(**P. squamosus*). Calyx compressed laterally; convex side composed of large plates arranged in cycles; flattened side covered with very minute plates; arms two; pectinate rhombs three, borne on convex side; anal opening at side of base; column short, tapering distally to a point. **Ord.**

***P. squamosus** Billings (**48**—4, 16). Large plates smooth; rhombs small, the longer axes of upper two transverse to length of calyx. **Trenton:** Que., Ont. (Hull); Mich.

P. filitextus Billings (**48**—20, 21). Longer axes of rhombs in same direction as calyx length; plates on flat side ten times larger than in *P. squamosus;* plates on convex side with strong ridges radiating from center to angles; between these are often other ridges crossing sides of plates at right angles, giving plates a striated appearance; calyx about the size and shape of *P. squamosus.* **Trenton:** Que., Ont. (Hull).

GLYPTOCYSTITES Billings 1854

(**G. multiporus*). Calyx elongate cylindrical, with four irregular series of plates; four plates in basal series and five in each succeeding; anal opening in one of the plates of second series; mouth at center of summit where it receives the five ambulacra, which are bordered by small plates; pectinate rhombs 10 to 15; column short, tapering to a point. **Ord.**

***G. multiporus** Billings (**49**—1–3). Four of the ambulacra extending to base of calyx, the fifth but a short distance; column with alternately wide and narrow joints; pore-rhombs irregularly placed. **Trenton:** Que., Ont. (Hull).

Order Diploporita. Radial symmetry in food grooves and also in associated calyx plates to some extent; food grooves extended over calyx plates themselves and prolonged to brachioles which line the calyx grooves; pectinate rhombs and pore-rhombs undeveloped; calyx plates may be folded and diplopores always present. **Ord., Sil.**

EUMORPHOCYSTIS Branson and Peck 1940

(**E. multiporata*). Calyx elongate, subcylindrical, possessing well developed stem facet, four basals, several hundred small polygonal diplopore-bearing plates, five small imperforate deltoids, and five small diplopore-bearing radials; ambulacra composed of adambulacrals, brachials, and small cover plates; mouth central, anal opening on right side in posterior interradius, and genital opening about halfway between mouth and anal opening, just outside anal deltoid. **Ord.**

***E. multiporata** B and P (**48**—22–24). **Simpson:** Okla. (L. Bromide).

GOMPHOCYSTITES Hall 1864

(**G. glans*). Elongate pyriform, composed of many ranges of granulose, closely applied, polygonal plates perforated by diplopores; mouth subcentral, anus eccentric; grooves sunk below thecal surface and curving spirally outward from mouth to greatest diameter of calyx; covering plates often developed. **Sil.**

***G. glans** Hall (**48**—13, 14). Elongate, abruptly expanding at summit; length of calyx 25 to 75 mm. **Niagaran** (Racine): Wis., Ill.

Order Aporita. Food grooves and calyx plates with radial symmetry; former borne on processes around oral center; no folds, rhombs or diplopores. **Camb.–Perm.?.**

LYSOCYSTITES Miller 1889

(= ECHINOCYSTITES Hall 1865)

(**Echinocystites nodosus* Hall). Small, spheroidal; characterized by nodes at four angles of plates of second series. **Sil.**

***L. nodosus** (Hall) (**49**—4–7). **Racine:** Wis.

CLASS EDRIOASTEROIDEA[1]

This class is a group of Paleozoic echinoderms which in their simplest form consist of a flexible theca or sacklike body composed of numerous polygonal plates. The mouth lies on the upper surface at the central point of radiation of five straight or curved ambulacra, which are separated by interambulacral plates. The anus with a valvular covering occupies part of an interray, with a hydropore located between it and the mouth.

These primitive echinoderms, free, or attached by a part of the lower surface, developed into attached flattened forms, elevated sacklike bodies, or cylindrical objects bearing the ambulacra at the top of a fused mass of plates. Starting at the left of the anal area and proceeding clockwise, the ambulacra are numbered and designated as follows: (1) left posterior; (2) left; (3) anterior — opposite anal area; (4) right; (5) right posterior. **Paleozoic.**

STROMATOCYSTITES Pompeckj 1896

(**S. pentangularis*). Theca depressed, pentagonally globular in form with oral surface bearing five narrow, straight ambulacra separated by polygonal, mosaic interambulacral plates with numerous intervening pores; under surface completely occupied by smaller, less regular polygonal plates; anal area slightly elevated, indistinct. **Camb.**

S. walcotti Schuchert (**49**—11). **L. Camb.:** Newf.

CYSTASTER Hall 1871

(= THECOCYSTIS Jaekel 1899)

(**Hemicystites granulatus*). Theca an elongate sack with lower end attached to some foreign object; ambulacra short, straight, five in number, with plates often rather nodose; interambulacrals rounded or polygonal, mosaic, very small (0.25 mm in diameter); anal pyramid of 10 elongated, abruptly raised plates. **Ord.**

***C. granulatus** (Hall) (**49**—9, 10). Usually grew on *Strophomena*. **U. Ord.:** Ohio (Maysville).

CINCINNATIDISCUS Bassler 1935

(**Agelacrinus* (*Hemicystites*) *stellatus* Hall). Like *Cystaster*, but theca is depressed or flat, attached by entire basal surface, and interambulacral plates are squamose, imbricating distinctly, and surrounded by a marginal zone of small nodose plates; anal pyramid of nodose plates. **Ord.**

***C. stellatus** (Hall) (**49**—17, 18). **U. Ord.:** Ohio (Maysville).

ISOROPHUS Foerste 1916

(**Agelacrinus cincinnatiensis* Roemer). Theca depressed, circular, attached by whole undersurface; ambulacra composed of two rows of plates (with an intercalated series often present), more or less curved, four (1 to 4) to left, and right posterior (5) to right; oral area occupied by numerous small plates;

[1] **Bassler, R. S.,** Classification of Edrioasteroidea: *SMC* 93 (8): 1–11, il, 1935; New species of American Edrioasteroidea: Idem (6): 1–33, pl 1–7, 1936. **Foerste, A. F.,** Notes on Agelacrinidae and Lepadocystinae, with descriptions of *Thresherodiscus* and *Brockocystis: DUB, JSL* 17: 399–474, il, 1914. **Hudson G. H.,** *Urasterella: N Y St Mus,* B 187: 117–164, il, 1916. **Raymond, P. E.,** Canadian species of *Agelacrinites: Ottawa Nat* 29: 53–62, 1915. **Williams, S. R.,** *Agelacrinites* and *Streptaster: Ohio J Sc* 19: 59–86, il, 1918.

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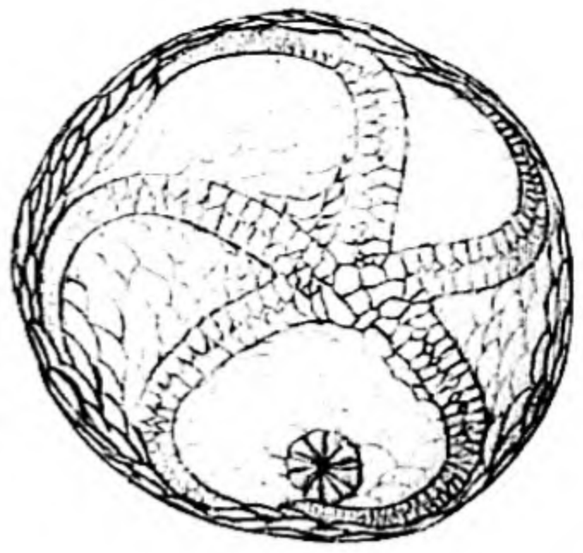

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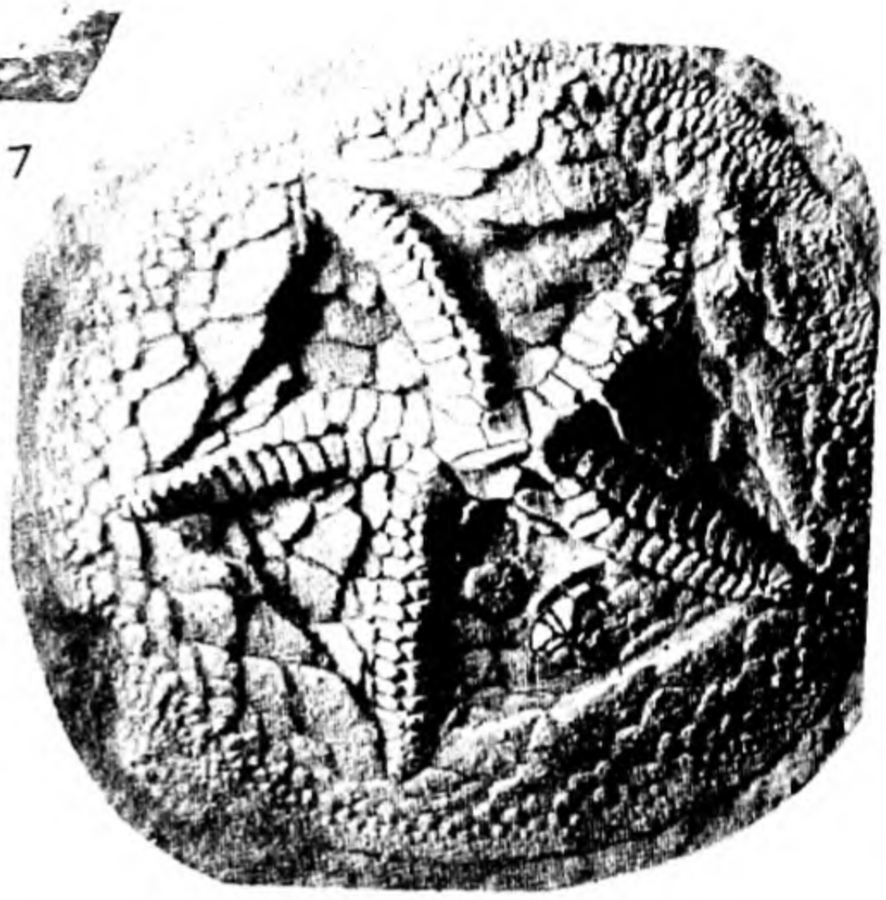

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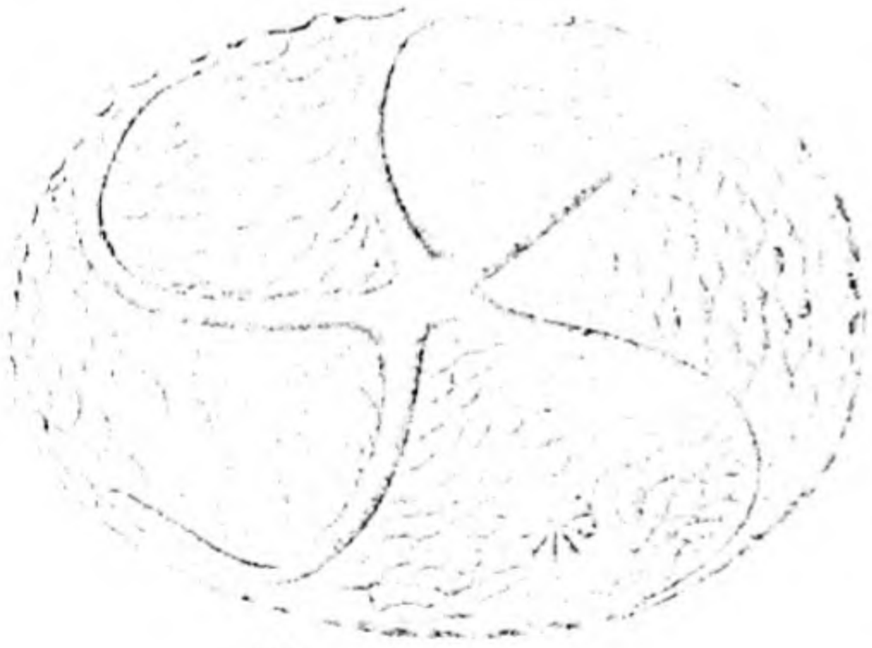

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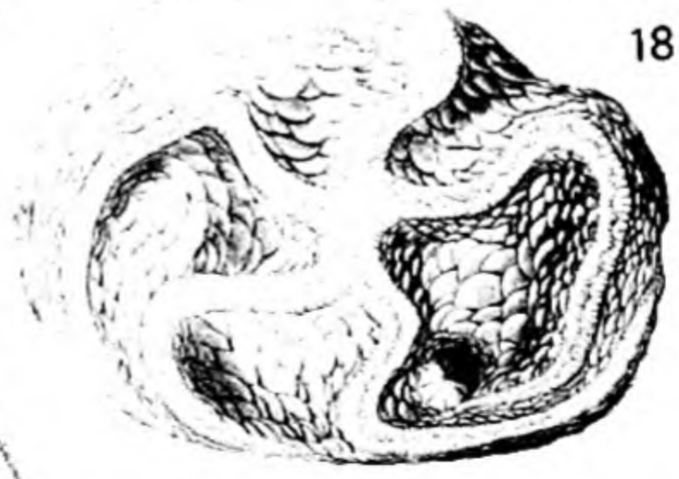

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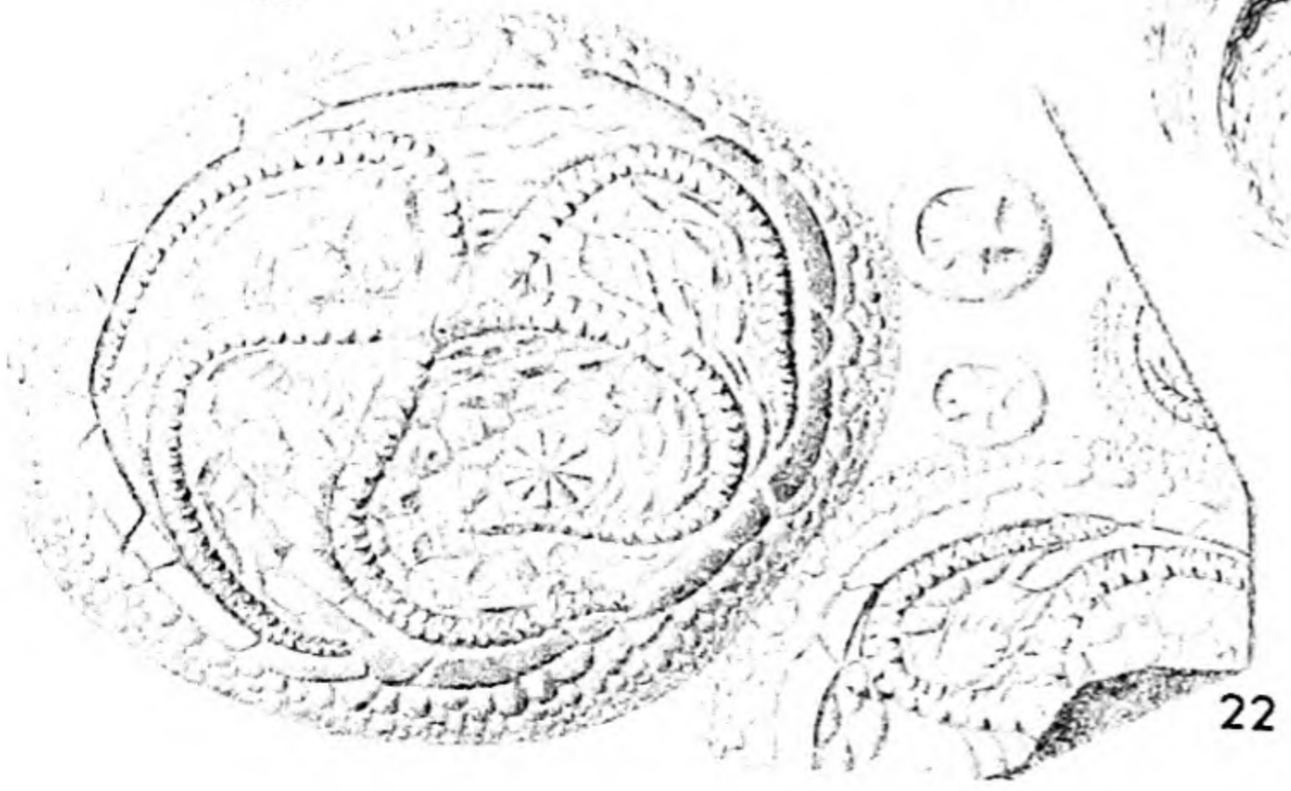

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margin composed of numerous rows of small plates slightly increasing in size inward; interambulacral plates polygonal, slightly imbricated; anal area a circle of triangular plates regularly arranged. **Ord.**

***I. cincinnatiensis** (Roemer) (**49**—8). Ambulacra sunk nearly to level of disk; usually found on *Rafinesquina alternata*. **Maysville:** Ohio, Ind., Ky., Tenn.

CARNEYELLA Foerste 1916

(**Agelacrinus* (*Lepidodiscus*) *pileus* Hall). Theca typically elevated, sacklike, attached by a broad, basal part, but also of depressed parasitic disks; ambulacra curved, four to left, right posterior to right; oral area of three plates, one large, next to anal region, and opposite these two small; surface of plates minutely pitted but often ornamented with conspicuous nodes and ridges. **Ord.**

C. nicklesi Bassler (**49**—12). **Trenton:** Ky. (Curdsville).

HEMICYSTITES Hall 1852

(**H. parasitica*). Theca a thin, flattened disk with oral arrangement and pitted plate structure of *Carneyella*, but ambulacra are short, broad, and straight; anal pyramid elevated and composed of a circle of regularly arranged, triangular plates. **Ord.–Dev., Penn.?.**

H. (Lebetodiscus) chapmani (Raymond) (**49**—15). **Trenton:** Ont.

***H. parasiticus** Hall (**49**—13). A *Carneyella* with broad, short, straight ambulacra and with squamose, imbricating overlapping plates; genus most prolific of all known edrioasteroids. **M. Sil.:** N. Y. (Lockport).

H. devonicus Bassler (**49**—23). Characterized by very short, rapidly tapering ambulacral rows. **Dev.:** Mich. (Ferron Point).

H.? carbonarius Bassler (**49**—14). **Penn.:** W. Va. (Bluefield).

AGELACRINITES Vanuxem 1842

(= AGELACRINUS of authors;
HAPLOCYSTITES Roemer 1852;
AGELACYSTIS Haeckel 1895;
HAPLOCYSTIS Haeckel 1896)

(**A. hamiltonensis*). Theca thin, attached by entire aboral surface; ambulacra five, long, narrow, much curved; two (4, 5) to right, three (1 to 3) to left; interambulacral plates sculptured, slightly imbricating; periphery formed by several rows of small plates followed by one row of much larger elongate ones; anal area a circle of regularly arranged, triangular plates. **Dev., Miss.**

***A. hamiltonensis** Vanuxem (**49**—22). **Hamilton:** N. Y.

DISCOCYSTIS Gregory 1897

(= ECHINODISCUS Worthen and Miller 1883 [not Agassiz]; AGELADISCUS Miller 1897)

(**Echinodiscus optatus* Worthen and Miller = *Agelacrinus kaskaskiensis* Hall). Like *Agelacrinites*, except that four ambulacra are curved to left and one, the right posterior (5), to right, and that body is well developed and sacklike with many rows of elongate, narrow marginal plates. **Miss.**

***D. kaskaskiensis** (Hall) (**49**—19, 20). **Miss.:** Ky. (Glen Dean), Ala. (St. Genevieve), Ill. (Chester), Mo.

COOPERIDISCUS Bassler 1935

(**Lepidodiscus alleganius* Clarke). Body depressed globular, free, entirely covered with plates; ambulacra long, very narrow, much curved, all turning to right; interambulacral plates strongly imbricate; anal pyramid of regular triangular plates meeting at a point. **Dev.**

***C. alleganius** (Clarke) (**49**—16). **U. Dev.:** N. Y., Pa.

LEPIDODISCUS Meek and Worthen 1868

(**Agelacrinites squamosus*). Like *Cooperidiscus*, but ambulacra 1 to 4 curve strongly to left, and 5, the right posterior, to right; interambulacral plates small, strongly imbricating; anal pyramid well developed. **M. Dev.–Miss.**

***L. squamosus** (M and W) (**49**—21). **M. Miss.:** Ind. (Keokuk).

EDRIOASTER Billings 1858

(= CYCLASTER Billings 1857)

(**Cyclaster bigsbyi*). Theca sacklike, flexible, attached by a small central portion of aboral surface; ambulacra pass from oral to aboral side; interambulacral plates mosaic; ambulacra strongly curved, four (1 to 4) to left, one to right; anal pyramid composed of many small plates irregularly arranged. **Ord.**

PLATE 49

[Figures are x1 and after Bassler [SMC 95] unless otherwise indicated.]

1–3. Glyptocystites multiporus [CGS, COR, d 3]. Anterior view of specimen with column attached; top view slightly enlarged; calyx plates spread out. **4–7. Lysocystites nodosus** [Ohio J Sc 21]. Lateral, top, and basal views of a specimen; specimen with anal aperture at lower margin of figure left of median line. **8. Isorophus cincinnatiensis** (x2) [Pal Ohio 1]. **9, 10. Cystaster granulatus** [Pal Ohio 1]. Side view of theca (x3); the same (x2). **11. Stromatocystites walcotti** (x2) [SMC 70]. A "natural mold" showing centrodorsal plate and ossicles of rim. **12. Carneyella nickelsi** (x4). Theca attached to a shell. **13–15. Hemicystites** spp. **13. H. parasiticus.** Holotype (x4). **14. H. carbonarius.** Holotype (x4), attached to a pelecypod shell. **15. H. (Lebetodiscus) chapmani.** Type (x3), showing long series of ambulacral plates. **16. Cooperidiscus alleganius** (x1.5) [N Y St Mus, B 49]. **17, 18. Cincinnatidiscus stellatus** (x2, x1) [17: Pal Ohio 1]. **19, 20. Discocystis kaskaskiensis.** Basal view of theca (x2) and a normal compressed theca (x1.3). **21. Lepidodiscus squamosus** [Ill G S 5]. **22. Agelacrinites hamiltonensis** (x2) [N Y St Mus, B 49]. A large adult and portions of several other individuals in various stages of growth. **23. Hemicystites devonicus.** The holotype (x4), incrusting a *Chonetes*. **24. Edrioaster bigsbyi.** Oral side of the flexible theca.

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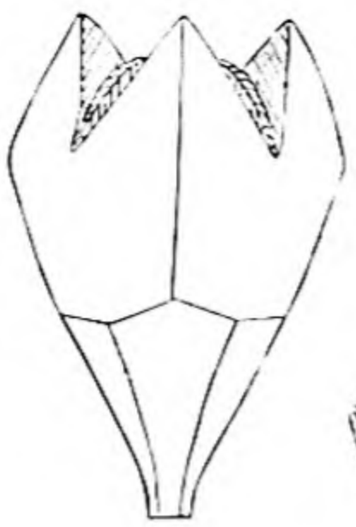

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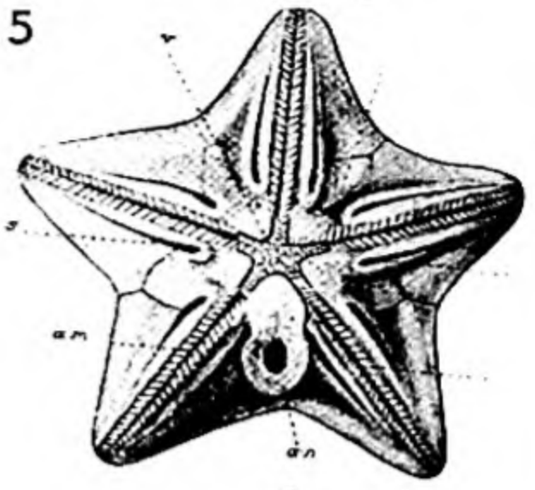

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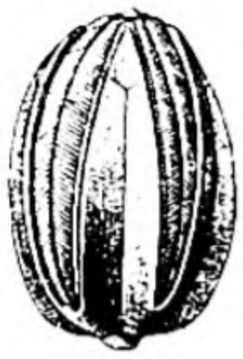

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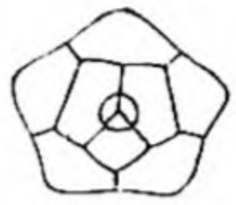

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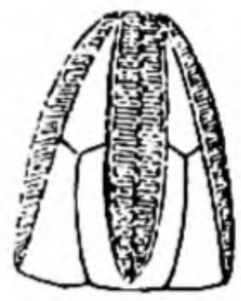

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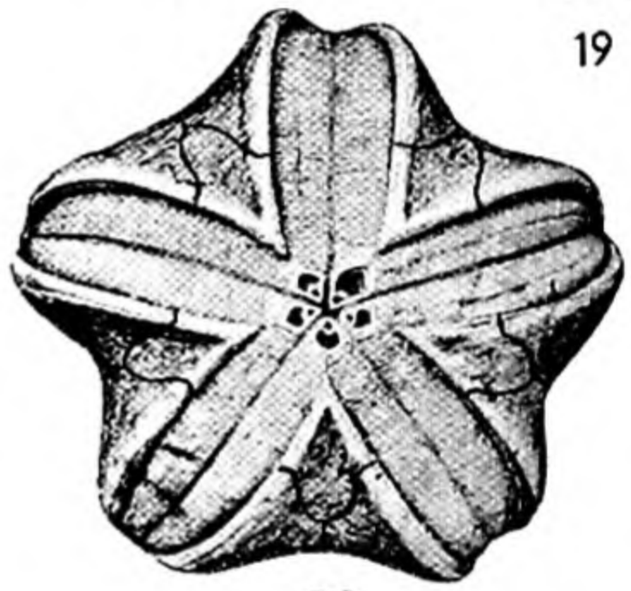

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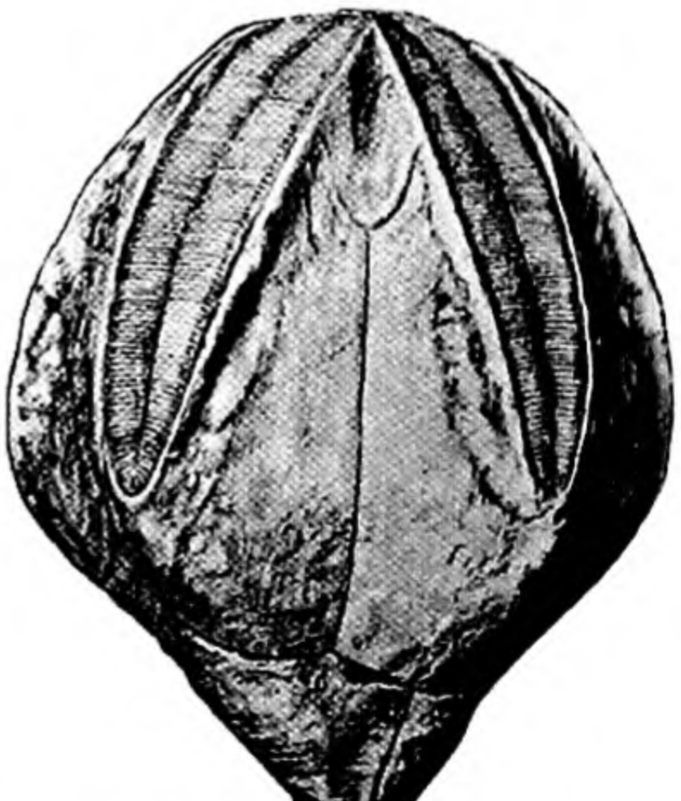

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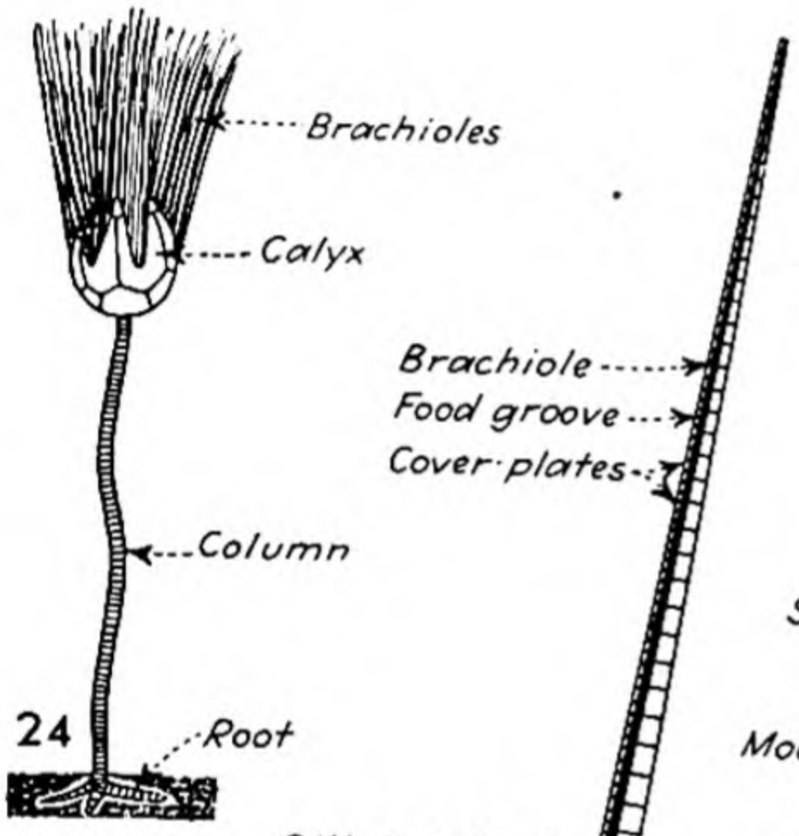

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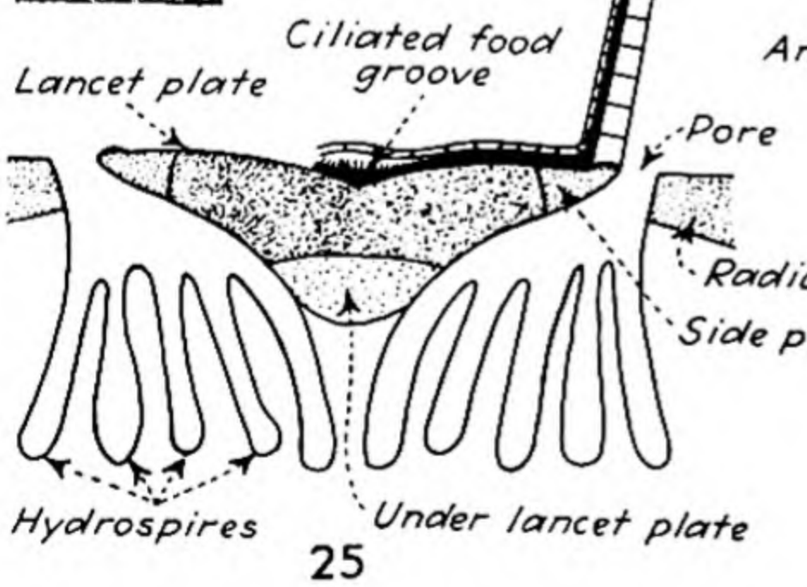

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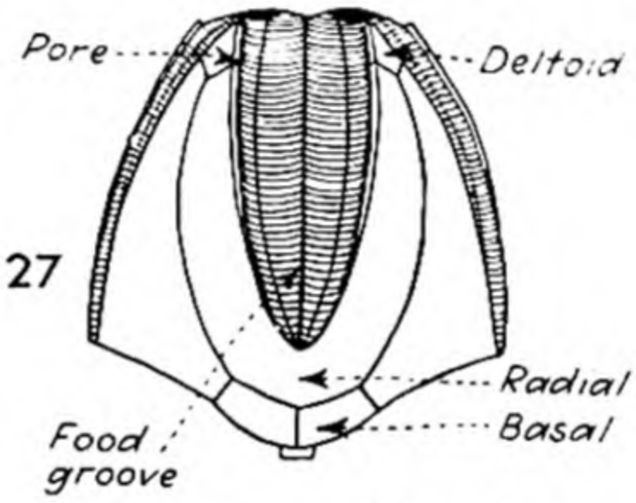

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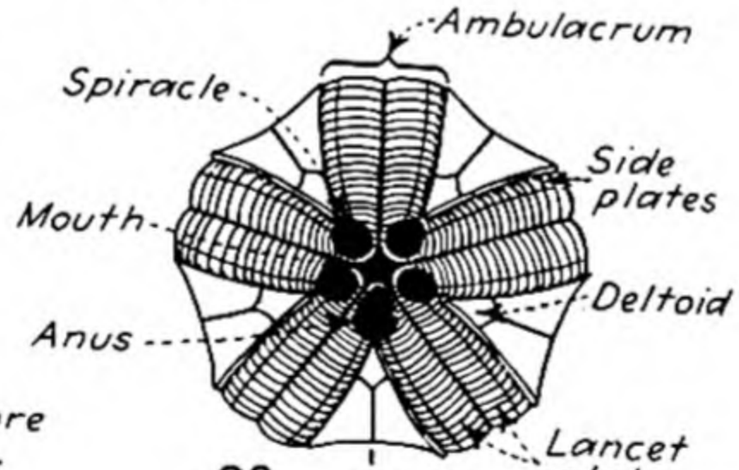

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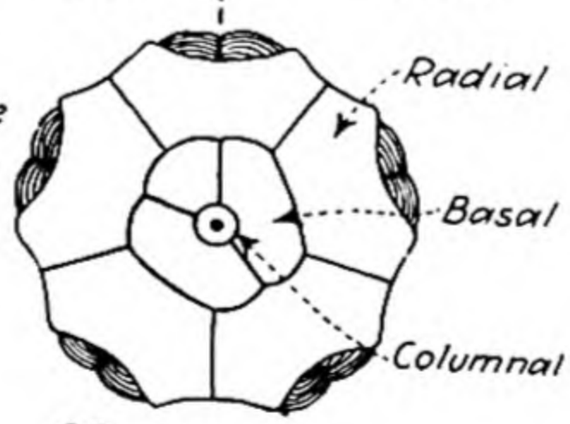

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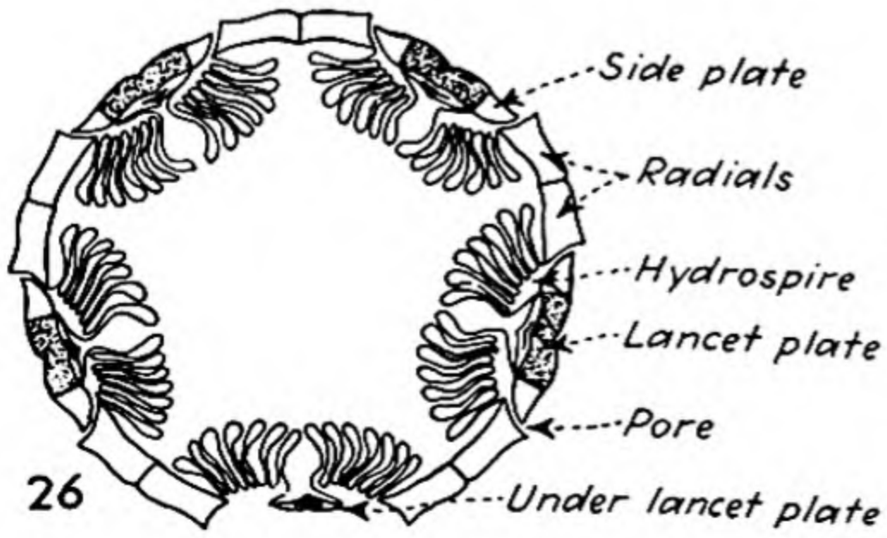

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***E. bigsbyi** (Billings) (**49—24**). **M. Ord.:** Ont. (Trenton); Mich. (Trenton), Ky. (Curdsville). Minn. (Prosser).

CLASS BLASTOIDEA[1]

REVISED BY LEWIS M. CLINE

Blastoids resemb e crinoids in having an ovoidal calyx affixed at the base to a short jointed column, but differ in lacking arms (see pl 50). Radiating from the centrally located mouth, on the upper surface, are five petaloid ambulacral areas. Rarely preserved but present in life were rows of jointed appendages (*pinnules*) which bordered and concealed the ambulacra, so that in appearance blastoids were not unlike a brush. Except in *Eleutherocrinus* and a few other forms, a stem was present but it is rarely preserved.

The calyx is typically composed of 13 principal plates, firmly knit, and arranged in three cycles; three *basals*, five *radials*, and five *deltoids*. The relative proportions of the three circlets of plates vary with the genus, but the deltoids are normally the smallest, the radials the largest.

Two basals are pentagonal, the third (*azygous basal*) is smaller and quadrate and invariably directed toward the right anterointerambulacrum. Resting upon the basals and alternating in position with them are the radials. The upper margin of each radial is notched by a V-shaped sinus which receives the aboral end of an ambulacrum. That part of the radial below the sinus is the *body*, that part above the sinus constitutes the *limbs*. Succeeding and alternating in position with the radials are the *deltoids*, so named because in many species the exposed portion is triangular. The junction of the deltoids and radials is an adorally or aborally sloping surface whose external expression is the slightly V-shaped radio-deltoid suture. In some genera the deltoids overlap the beveled upper edges of the radial limbs, in others the radials overlap a considerable portion of the deltoids.

The ambulacra vary in form from petaloid to linear. Each ambulacrum consists of a narrow, longitudinal *lancet plate* partly covered with two rows of small transversely elongated *side plates* whose outer edges rest against the radials and deltoids. Upon the outer edges of the side plates in some genera is a row of still smaller plates, the *outer side plates*. Small pits or tubercles on the side plates indicate the places where pinnules were attached. Food was caught by the pinnules, passed transversely between the side plates to the longitudinal food grooves, and thence moved upward into the mouth.

The *peristome*, of which the mouth was a part in the living animal, is open in most fossils but in well preserved specimens is covered by a pentagonal integument of many small irregular plates which extend downward over the upper ends of the ambulacra, thus inclosing the food grooves. Bordering the peristome are several circular or slitlike openings, the *spiracles*, by which water was exhaled from the respiratory appartus (the *hydrospires*), and from a slightly larger opening, the *anus*. For each of the five rays there is a spiracle, or two spiracles, and where the anus is confluent with the posterior spiracle, that opening is larger than the other spiracles. Depending on whether the spiracles are single or paired, and the anus separate or fused, there are 5 (*Pentremites*), 9 (*Cryptoblastus*), or 11 openings (*Acentrotremites*) around the peristome. In most genera each spiracle notches the lateral edge of a deltoid and is bounded by side plates and the lancet, but in *Orbitremites* the spiracles pierce the deltoids.

[1] **Barris, W. H.,** New blastoids from the Hamilton group: *Ill G S* 7: 357–364, il, 1883; *Davenport Ac Sc*, Pr 4: 88–94, 1884. **Bather, F. A.,** Genera and species of Blastoidea in the British Museum. P 1–70, 1899. **Cline, L. M.,** Blastoids of Osage group, Mississippian, I, *Schizoblastus: J P* 10: 260–281, il, 1936; II, *Cryptoblastus: JP* 11: 634–649, il, 1937. **Croneis, C.,** and **Geis, H. L.,** Ontogeny of the Blastoidea: *JP* 14: 345–355, 1940. **Etheridge, R.,** and **Carpenter, P. H.,** Catalogue of Blastoidea in the British Museum. P 1–322, pl 1–20, 1886. **Greger, D. K.,** Bibliographic index of North American species of Eublastoidea: *Ac Sc St L*, Tr 28: 121–181, 1934. **Hambach, G.,** Revision of the Blastoidea: *Ac Sc St L*, Tr 13: 1–67, pl 1–6, 1903. **Meek, F. B.,** and **Worthen, A. H.,** Echinodermata: *Ill G S* 3 (2): 450–565, pl 14–20, 1868; Idem 5: 323–619, pl 1–32, 1873. **Moore, R. C.,** Early growth stages of Carboniferous microcrinoids and blastoids: *JP* 14: 572–583, 1940. **Peck, R. E.,** Blastoidea of the Chouteau of Missouri: *U Mo Stud* 13 (4): 57–69, il, 1938. **Reimann, I. G.,** Middle Devonian blastoids: *Buffalo Soc N H*, B 17: 43–45, il, 1935. **Rowley, R. R.,** New Echinoderma from Mississippian of Missouri: *Kansas City Scientist* 5: 97–103, 113–118, 1891; *Am G* 12: 303–309, 1893; *Am G* 25: 65–75, 1900. **Wanner, Joh.,** Die Permischen Echinodermen von Timor, Teil II, 1924.

PLATE 50

[Figures are x1 unless otherwise indicated.]

1–5. Codaster spp. 1–3. C. gracilis [Davenport Ac Sc, Pr 4; also Ill G S 7]. Horizontal section of hydrospires (x5); side view of a specimen (x3); top view (x3). **4, 5. C. pyramidatus** [Cat Blastoidea British Mus 1886]. Summit (x2.6) and lateral views (x2). **6–9. Orophocrinus spp. 6, 7. O. conicus** [Ill G S 8]. Top and side views of a specimen enlarged. **8, 9. O. stelliformis** [Ill G S 5]. Side and basal views of a small calyx, and enlarged top view of another specimen. **10–21. Pentremites spp. 10. P. elongatus** [Mo G S 4]. **11–13. P. conoideus** [Ia G S 1 (2)]. An adult specimen; side and basal views of another calyx. **14, 15. P. godoni** [Ia G S 1 (2)]. Lateral and basal views. **16–18. P. angustus.** Lateral view of a calyx [DUB, JSL 18]; diagrammatic basal and lateral views [Ac Sc St L, Tr 13]. **19. P. pyriformis** [Ia G S 1 (2)]. Specimen with portion of column attached. **20, 21. P. obesus** [USGS, PP 36]. Summit and lateral views of well preserved specimens. **22, 23. Pentremitidea spp. 22. P. americana** [Davenport Ac Sc, Pr 4]. **23. P. filosa** [CGS, Contr Can Pal 1]. **24–30.** Diagrammatic figures illustrating the chief internal and external features of a blastoid [after Twenhofel and Shrock, "Invertebrate Paleontology," by permission of McGraw-Hill Book Co., Inc.]. 24: An attached blastoid in living position. 25: Cross section of the midportion of an *Amb* with a brachiole shown along the right margin. 26: Cross section of the calyx of *Pentremites pyriformis* at about the midpoint of the *Amb*, with one *Amb* removed. 27–29: Lateral, oral, and basal views of a calyx. 30: Analysis of main calyx plates (B, basal; R, radial; D, interradial or deltoid).

Water entered the respiratory system through the hydrospire pores, which notch the outer edges of the side plates, passed into lamellar pleated tubes (the hydrospires), moved upward and was discharged through the spiracles. Hydrospires are peculiar to the blastoids. The folds appear at about the level of the radial sinus and extend vertically upward; the inner edge of each fold expands bulblike and is directed toward the center of the calyx. In *Schizoblastus* the hydrospires first appear as infolds of the radials, the plate substance being continuous in the two structures. In other genera the lower ends of the hydrospires are lodged in the substance of the radials.

Blastoids are an exclusively Paleozoic group, ranging from **Ordovician** to **Permian** with maximum development in the **Mississippian.**

CODASTER McCoy 1849

(**C. trilobatus*). Calyx conical, acutely pointed below and truncated above, periphery near summit; transverse section pentagonal; basals and radials long, subequal; radials only slightly notched by sinuses, limbs bent sharply inward and forming part of truncated summit; deltoids small, wholly confined to summit; four triangular and bearing a median longitudinal ridge, the fifth minus the ridge and pierced by a large oval anus; ambulacra short, petaloid to linear, confined to summit; eight groups of hydrospires, two in each interradius except the posterior one, a variable number of folds (2 to 10 observed) in each group; spiracles absent, the hydrospires opening externally through elongated slits which penetrate truncated inner edges of radial limbs and adjacent portions of deltoids. **Sil.–Miss.**

C. gracilis (Wachsmuth) (**50**—1–3). Calyx devoid of ornamentation; *Amb* short, linear, deeply depressed below *IAmb* ridges; eight to nine hydrospire slits, inner two covered by overhanging lancet. **Dev.:** Mich. (Thunder Bay).

C. pyramidatus Shumard (**50**—4, 5). Summit convexly rounded; radials bear flattened marginal bands; *Amb* project above sinus margins; seven or eight hydrospire slits, one partly concealed. **M. Dev.** (Onondaga): N. Y., Ohio, Ky.

OROPHOCRINUS Seebach 1864

(**Pentremites stelliformis* Owen and Shumard). Like *Codaster* in general shape and arrangement of plates but differs in having spiracles (10) and 10 groups of hydrospires, 2 groups in posterior *IAmb*; slitlike spiracles at sides of *Amb* represent unclosed portions of radial sinuses and are the only means by which hydrospires communicate with the exterior; posterior pair separate from anus. **Miss.**

***O. stelliformis** (O and S) (**50**—8, 9). Calyx large, expanding gradually upward to basi-radial sutures and thence rapidly to radial sinus but contracted above into convexly rounded summit; lateral outline parachute-shaped; transverse section stellate; distance from peristome to proximal side plates relatively great. **Burlington:** Ill., Ia., Mo., Ark.

O. conicus (Wachsmuth and Springer) (**50**—6, 7) Calyx small, expanding gradually upward, summit convex; *Amb* short, flush with summit; ornamented with fine lirae parallel to plate margins. **U. Kinderhook:** Ia. (Hampton).

PENTREMITES Say 1820

(= PENTREMITE Sowerby 1825)

(**Encrina godoni* Defrance). Calyx ovoidal to pyriform, budlike in appearance; periphery variable, typically equatorial; transverse section pentagonal but not stellate; basals small, forming a depressed funnel-shaped cup; radials long, forming greater part of calyx, deeply notched by sinuses; bodies short, limbs long; deltoids small; *Amb* broad, petaloid; side plates rest against lancet but do not cover any part of it; three to nine hydrospire folds; hydrospire pores present; hydrospire tubes of each *IAmb* typically fused, producing five spiracles, but fusion may be incomplete; posterior spiracle fused with anus, that being the largest opening. **Miss., Penn.**

P. elongatus Shumard (**50**—10). About twice as long as broad; periphery equatorial; *Amb* reach almost length of body; spiracles typically single, imperfectly divided in some specimens; grades from robust variety with broad base to more attenuate variety. **Burlington:** Ia., Mo., Okla.

P. conoideus Hall (**50**—11–13). Like *P. elongatus* but smaller, more conical, and base flatter. **Keokuk:** Mo.; **Warsaw:** Ind., Ill., Ala.; **Salem:** Ind.; **St. Louis:** Ind., Ky., Ill., Ala., Mo.; **Brazer:** Utah, ?Mont.

***P. godoni** (Defrance) (**50**—14, 15). Calyx more globular than in *P. elongatus*. **Chester:** W. Va., Ky., Tenn., Ga., Ala., Ill., Mo.; **Brazer:** Utah, ?Mont.

P. obesus Lyon (**50**—20, 21). Calyx subglobose, very large and massive. **Chester:** Ky., Ill., Mo.

P. pyriformis Say (**50**—19, 26). Calyx pyriform; periphery equatorial, tapering at both ends; base more elongate than in *P. godoni*; *Amb* reach little more than half length of calyx. **Chester:** Ind., Ky., Tenn., Ala., Ill., Mo.

P. angustus Hambach (**50**—16–18). Conical, elongate, periphery near base, summit contracted; base small, almost flat; deltoids relatively long; *Amb* reach almost height of calyx. **Morrow:** Ark., Okla.

P. rusticus Hambach. Barrel-shaped rather than conical, as wide as high; *Amb* broad, depressed below sinus borders. **Morrow:** Okla.

PENTREMITIDEA Orbigny 1849

(**Pentremites pallettei* Verneuil). Calyx clavate to clove-shaped, summit truncate to convex, base long and conical; hydrospires, spiracles, and distribution of plates as in *Pentremites*, but deltoids are inconspicuous; lancet largely concealed by side plates. **Dev.**

P. filosa Whiteaves (**50**—23). Periphery below equator; clavate. **Hamilton:** Ont.; Mich., Wis.

P. americana Barris (**50—22**). Distinguished from *P. filosa* by a relatively longer, more conical base and correspondingly shorter *Amb*. **Traverse:** Mich.

P. goldringae Reimann. Base more attenuate than in *P. filosa*; *Amb* shorter. **Hamilton:** N. Y.

TROOSTICRINUS Shumard 1865

(= TROOSTOCRINUS Meek and Worthen 1868)

(**Pentremites reinwardti* Troost). Calyx subfusiform, greatly elongated, summit subtruncate; periphery one-third distance from summit, where transverse section is pentagonal; base long and tapering, rounded above, distinctly triangular below; basals comprise one-third length of calyx, radials other two-thirds; radials narrow, limbs much shorter than bodies and inclined inward toward summit; the four anterior deltoids entirely overlapped by radials, the posterior one visible externally and rhombic; *Amb* short, narrow, deeply impressed; lancet completely covered by side plates; spiracles five, the four anterior ones imperfectly divided by deltoid ridges, the posterior one confluent with anus; three hydrospires on each side of an *Amb*. **Sil.**

***T. reinwardti** (Troost) (**51—2**). Strongly geniculated at radial lips; spiracles almost completely divided by deltoid crests. **Niagaran:** Ky., Tenn.

METABLASTUS Etheridge and Carpenter 1886

(**Pentremites lineatus* Shumard). Resembling *Troosticrinus* in general shape but periphery more nearly equatorial; base strongly trihedral but section becomes distinctly pentagonal near basi-radial sutures; deltoids small, inconspicuous, overlapped but not completely hidden by radials; *Amb* short, deeply impressed; side plates conceal lancet; 10 slitlike spiracles, the posterior pair separate from anus and nearer peristome; four hydrospires on each side of *Amb*; differs from *Troosticrinus* chiefly in structure of spiracles and in deltoids being equal and exposed. **Dev., Miss.**

***M. lineatus** (Shumard) (**51—8**). Calyx long, spindle-shaped, periphery one-third distance from top; basals long. **Burlington:** Ill., Ia., Mo.

M. bipyramidalis (Hall) (**51—7**). Periphery a little below equator; summit and base truncate; *Amb* longer than in *M. lineatus* and basals shorter. **Keokuk:** Mo.; **Warsaw:** Ind.

TRICOELOCRINUS Meek and Worthen 1868

(**Pentremites* (*Troostocrinus*) *woodmani*). Closely related to *Metablastus*, strongly resembling it in size and structure of deltoids and in having posterior pair of spiracles separated from anus, but differing in shape of calyx and structure of hydrospires; calyx subpyramidal, broadly rounded below, contracting gradually above and truncated at summit; periphery typically below midheight; base trihedral, excavated along interbasal sutures, the excavations extending to lower part of three of the radials; radials carinate in median portion below lips; deltoids small, equal; *Amb* remarkably linear, longer than in *Metablastus* and *Troosticrinus*; 10 spiracles, the posterior pair not fused with anus; hydrospires small, lower portions inclosed within substance of radials. **Miss.**

***T. woodmani** (Meek and Worthen) (**51—13–16**). Calyx large, largest below and rounded, tapering upward; basals short, strongly carinate longitudinally. **Warsaw:** Ind., Mo.

NUCLEOCRINUS Conrad 1842

(**N. elegans*). Calyx olive-shaped, smaller below; basals small, commonly hidden in a basal concavity; radials small, limbs short, lips prominent; deltoids forming more than two-thirds of calyx; posterior deltoid wider than others and divided by a longitudinal anal plate; *Amb* very long, narrow, lancet partly exposed; two hydrospires on each side of an *Amb*; five pairs of spiracles notch upper ends of deltoids, the posterior pair being smaller than the others and distinct from anus. **Dev.**

N. verneuili (Troost) (**51—3–6**). Radials very short, with scarcely any subdivision into bodies and limbs. **Onondaga:** Ohio, Ind., Ky., Tenn., Ill., Mo.

N. obovatus (Barris) (**51—9**). Calyx large, more elongated than in other described species of genus. **Traverse:** Mich. (Thunder Bay); **Cedar Valley:** Ia.

N. bondi Thomas (**51—10–12**). Cross-section stellate; *Amb* linear, strongly elevated; median areas of deltoids sunken. **Cedar Valley:** Ia.

SCHIZOBLASTUS Etheridge and Carpenter 1882

(**Pentremites sayi* Shumard). Calyx melon-shaped to subglobose; base typically concave but may protrude slightly; basals and bodies of radials take part in basal concavity; radials usually reach less than one-half height of calyx; upper edges of limbs beveled, lower edges of deltoids overlapping this sloping surface; deltoids commonly comprising more than half length of calyx; posterior deltoid divided into epideltoid and hypodeltoid plates by a suture transverse to anus; *Amb* reaching almost height of calyx, commonly narrow; median portion of lancet exposed, width of exposure decreasing aborally; no hydrospire plate; hydrospire pores present throughout length of *Amb*; two hydrospires on each side of an *Amb*, their substance continuous with radials aborally; 10 small slitlike spiracles excavated in lateral edges of deltoids, bordered by lancet and side plates; posterior spiracles separated from anus. **Miss.–Perm.**

S. etheridgei Cline (**51—24–26**). Calyx melon-

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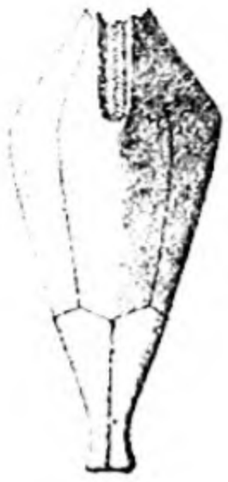

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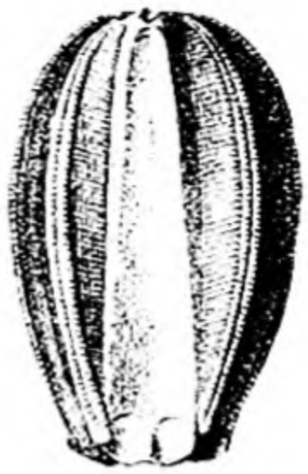

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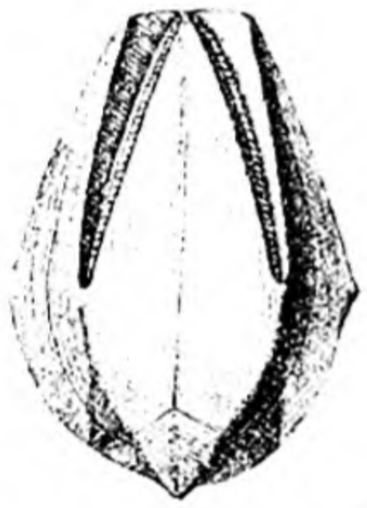

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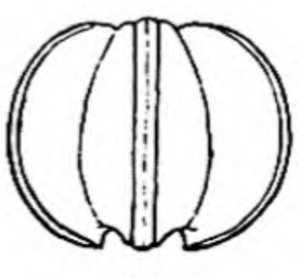

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shaped, higher than wide, base almost flat; periphery equatorial; transverse section strongly decagonal because of projecting *Amb* and *IAmb* ridges; radials unusually long, reaching four-fifths length of calyx. **Burlington:** Ia.

***S. sayi** (Shumard) (**51**—17–23). Subglobular, base concave, radial lips strongly protruding, section almost circular at periphery but becoming pentagonal aborally; deltoids reach 0.75 length of calyx. **Burlington:** Ia., Mo.

CRYPTOBLASTUS Etheridge and Carpenter 1886

(**Pentremites melo* Owen and Shumard). Differs from *Schizoblastus* chiefly in presence of hydrospire plate, absence of *Amb* pores above radio-deltoid suture, and in size and structure of deltoids; radials larger than deltoids and overlapping their truncated lower edges; eight small spiracles, the posterior pair fused with anus. **Miss.**

C. roemeri (Shumard) (**51**—29–31). Distinguished by its shape and ornamentation. **Chouteau:** Ia., Mo.

***C. melo** (O and S) (**51**—32–34). Larger than *C. roemeri* and ornamentation different; surface granular. **Burlington:** Ill., Ia., Mo.

C. granulosus (Meek and Worthen) (**51**—27, 28). Smaller than *C. melo* and deltoids relatively larger than in *C. melo* and *C. roemeri*. **Burlington:** Ia., Mo.; **Keokuk:** Ill.

C. pisum (Meek and Worthen) (**51**—35, 36). Distinguished by its small size, subglobular calyx larger above than below, and an almost circular transverse section above equator. **Burlington:** Ia., Mo.; **Lake Valley:** N. Mex.

ORBITREMITES Gray 1840

(**Pentremites derbiensis* Sowerby). Like *Schizoblastus* and *Cryptoblastus* in general appearance; basals small, commonly concealed in basal concavity; radials variable in size, typically longer than deltoids, and invariably turned in below to form part of base; *Amb* long, narrow; hydrospire plate present; spiracles five, piercing apices of deltoids, the posterior spiracle larger, being fused with anus. **Miss.**

O. norwoodi (Owen and Shumard) (**51**—37–41). Calyx globose, basal cavity deep and funnel-shaped; all spiracles except the anal extended into erect tubular openings. **Burlington:** Ill., Ia., Mo.

CLASS CRINOIDEA[1]

PREPARED BY RAYMOND C. MOORE AMD LOWELL R. LAUDON

The crinoids, sometimes called sea-lilies or feather-stars, are marine invertebrates characterized by a body covering of crystalline calcite plates, by jointed arms that radiate from the body, and in general by a stem that fixes the animal to the substratum. Crinoids are represented in modern seas by several hundred species. They live at depths ranging from very shallow water to about 3,000 fathoms, but many are free-swimming and are attached by a stem only during larval life. Crinoids first appear in Ordovician rocks, and at times in the Paleozoic were so abundant that their skeletal remains now form the major part of some rock formations.

The hard parts of a crinoid (see "Symbols for crinoid parts," by R. C. Moore and L. R. Laudon, *JP* 15: 412–423, 1941) are plates that inclose the body and support the arms, all of these together being called the *crown*, and except in the stemless forms there are also the very numerous superposed plates that comprise the *stem* or *column*. The part

[1] Note: The titles listed below will be referred to in the text and plate captions by the number preceding the reference. Because of condensation some titles are incomplete.

(1) **Austin, T.** and **T., Jr.**, Recent and fossil Crinoidea, 1–128, pl 1–16, 1843–1849, London and Bristol. (2) **Bassler, R. S.**, Pelmatozoa Palaeozoica: *Fos Cat*, pars 83: 1–194, 1938. (3) **Bather, F. A.**, Crinoidea, in **Lankester's** Treatise on Zoology, pt. 3: 94–204, 1900, London; (4) The species of *Botryocrinus: Ottawa Nat* 20: 93–104, 1906; (5) I, *Ottawacrinus;* II, *Merocrinus: CGS, Victoria Mem Mus*, B 1: 1–14, 1913; (6) Triassic crinoids from New Zealand: *G Soc London*, QJ 73: 247–256, 1918. (7) **Beede, J. W.**, New fossils from Kansas coal measures: *Kan U Quart* 8: 123–130, 1899; (8) Two new crinoids from Kansas Carboniferous: Idem 9: 21–24, il, 1900; (9) Carboniferous invertebrates: *Kan G S* 6 (2): 26–45, il, 1900; (10) New fossils from Upper Carboniferous of Kansas: *Kan U Sc B* 1, 147–153, il, 1902; (11) Fauna of the Salem limestone of Indiana: *Ind G S*, An Rp 30: 1243–1270, pl 7, 12–17, 26. 1906. (12) **Billings, E.**, Fossils of the Upper Silurian rocks: *Can Nat Geol* 1: 57–60, il, 1856; (13) New species from Silurian rocks of Canada: *CGS*, Rp Prog 1853–1856: 256–345, 1857; (14) Crinoidea of Lower Silurian rocks of Canada: *CGS, Can Org Rem*, dec 4: 7–66, pl 1–10, 1859. (15) **Boos, M. F.**, Luta limestone (Permian) of Oklahoma and Kansas: *JP* 3: 241–253, il, 1929. (16) **Branson, E. B.**-

PLATE 51

[Figures are x1 unless otherwise indicated.]

1. Devonoblastus leda [N Y St Cab, Rp 15]. **2. Troosticrinus reinwardti** [Roemer: Sil Fauna West Tenn]. **3–6. Nucleocrinus verneuili** [USNM, B 64]. Four views of a specimen. **7, 8. Metablastus spp. 7. M. bipyramidalis** [Ia G S 1 (2)]. **8. M. lineatus** [Ac Sc St L, Tr 1]. **9–12. Nucleocrinus spp. 9. N. obovatus** [Davenport Ac Sc, Pr 4]. **10–12. N. bondi** [Ia G S 29]. 10, 12: Summit and side views of a specimen; 11: Side view of type. **13–16. Tricoelocrinus woodmani** [Cat Blastoidea British Mus 1886]. A complete calyx; anal portion enlarged (x2); basal and summit views. **17–26. Schizoblastus spp.** [JP 10]. **17–21. S. sayi bellulus.** 17: Right postero-interambulacral view. 18: Left postero-ambulacral view. 19, 20: Summit views. 21: Basal view. **22, 23. S. sayi obesus** (x4). Diagrammatic cross sections just below radio-deltoid suture and just above periphery, showing hydrospire structure. **24–26. S. etheridgei** (x2). Summit, and two side views of holotype. **27–36. Cryptoblastus spp. 27, 28. C. granulosus** (x4) [JP 11]. Right antero-ambulacral and antero-ambulacral views. **29–31. C. roemeri** (x2) [U Mo Stud 13 (4)]. Summit, postero-interambulacral, and basal views. **32–34. C. melo** (x2) [JP 11]. Right postero-interambulacral view, right antero-ambulacral view, and summit view. **35, 36. C. pisum** [Ill G S 5]. Summit and lateral views enlarged (x2). **37–41. Orbitremites norwoodi.** Side, basal, and summit views [Geol Rp Wis, Ia, Minn 1852], outline of a rotund form, and portion of summit enlarged (x2) [Cat Blastoidea British Mus 1886].

of the crown that includes all except the arms is termed the *calyx*. This incloses the crinoid viscera, including especially a spirally coiled *gut*, and bears the *mouth* and *anal vent*. The part of the calyx below the arm bases is the *dorsal cup*, and the remaining part the *ventral disk* or *tegmen*. The *arms* are free appendages that radiate from the calyx. They function mainly in the gathering of food and may be variously branched or unbranched.

The dorsal cup corresponds to the apical or abactinal parts of other echinoderms such as the echinoids and asteroids, but in the crinoids the dorsal surface is directed downward and the ventral or oral surface upward. The cup is composed of plates that have a constant arrangement in each genus. In all crinoids the lowermost plates of the cup are disposed in horizontally placed circlets, plates of one circlet alternating in position with those of the adjoining circlet.

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The upper part of the dorsal cup may consist partly of plates arranged in vertical series. The lowermost plate in direct vertical series with one of the main arm trunks or rays — typically five, and never more than five in number — is designated a *radial* (sing. R, plural RR). In some primitive types of Paleozoic crinoids, however, the two lowermost plates of some rays are classed together as a *compound radial*, the lower being called an *inferradial* and the upper a *superradial*. Next below the RR and alternating in position with them is a circlet of *basal* plates (sing. B, plural BB). Many crinoids have only this one circlet of plates below the RR and these are termed *monocyclic crinoids*; the BB are attached to the stem. Modern crinoids and a very large number of fossil forms show the presence of a plate (*centrodorsal*) or a circlet of plates, called *infrabasals* (symbol IB, plural IBB), below the BB and alternating with them. These are *dicyclic crinoids*

Plates of the rays that occur above the RR are

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52

RA or sRA
iRA
Ax
R
X

1 ANAMESOCRINIDAE
ANAMESOCRINUS

2 HAPLOCRINITIDAE
HAPLOCRINITES

3 HYBOCRINIDAE
HYBOCRINUS
HYBOCYSTITES

4 ALLAGECRINIDAE
Orals
KALLIMORPHO CRINUS
ALLAGECRINUS
CATILLOCRINUS
ALLOCATILLOCRINUS

5 OTTAWACRINIDAE
LASIOCRINUS
OTTAWACRINUS

6 DENDROCRINIDAE
DENDROCRINUS

7 HOMOCRINIDAE
SYNCAULOCRINUS
ECTENOCRINUS
DRYMOCRINUS
HOMOCRINUS
DAEDALOCRINUS

8 ANOMALOCRINIDAE
ANOMALOCRINUS

9 BOTRYOCRINIDAE
BOTRYOCRINUS

10 SYNBATHOCRINIDAE
SYNBATHOCRINUS

11 HETEROCRINIDAE
DYSTACTOCRINUS
ISOTOMOCRINUS
HETEROCRINUS

12 CYATHOCRINITIDAE
CYATHOCRINITES

13 ZEACRINITIDAE
NEOZEACRINUS

23 AMPHERISTOCRINIDAE
VASOCRINUS

14 PELECOCRINIDAE
STELLAROCRINUS

16 CUPULOCRINIDAE
CUPULOCRINUS

15 IOCRINIDAE
IOCRINUS

17 SCYTALOCRINIDAE
DECADOCRINUS

CARABOCRINIDAE
19
CARABOCRINUS

18 POTERIOCRINITIDAE
POTERIOCRINITES

PALAEOCRINIDAE
22
PALAEOCRINUS
POROCRINUS

20 CERCIDOCRINIDAE
CERCIDOCRINUS

BLOTHROCRINIDAE
21
CULMICRINUS

termed *brachials* (sing. Br, pl. BrBr), whether they form part of the dorsal cup or the free arms, but those incorporated in the cup are termed *fixed brachials* (sing fBr, pl. fBrBr). All BrBr up to the first forking of plates in a ray are designated as *primibrachials* (sing. PBr, pl. PBrBr). The rows of BrBr that occur above the first forking and as far as a second bifurcation are called *secundibrachials* (sing. SBr, pl. SBrBr). In like manner higher BrBr may be differentiated as *tertibrachials* (sing. TBr, pl. TBrBr), *quartibrachials* (sing. QBr, pl. QBrBr), *quintibrachials* (sing. VBr, pl. VBrBr), etc. The ray plates that support two branches are called *axillaries* (sing. Ax, pl. AxAx). The dorsal cup of some crinoids includes BrBr as high as VBrBr, but in many crinoids no BrBr are incorporated in the cup.

A few crinoids are distinguished by the presence of plates that intervene in the circlet of RR so as to separate each from its neighbors; these plates are termed *interradials* (sing. IR, pl. IRR). Plates that occur between BrBr of different rays are designated *interbrachials* (sing. IBr, pl. IBrBr); those between SBrBr are called *intersecundibrachials* (sing. ISBr, pl. ISBrBr), and those between TBrBr are called *intertertibrachials* (sing. ITBr, pl. ITBrBr). Plates of all these categories may occur in dorsal cups.

The posterior interradius of the dorsal cup of crinoids commonly shows variation from other interrays, and features of the posterior region have importance in classification of crinoids. The *radianal* (RA) is a plate that typically occurs obliquely below the *right posterior radial* (RPR) at its left, but primitively it may occur directly below the RPR and it may migrate upward to a place beside the RPR. Some primitive crinoids have an *inferradianal* (iRA) and *superradianal* (sRA), instead of a RA. Many crinoids have no RA. Another plate that commonly occurs directly above the *posterior basal* (PB) is considered the lowest plate of the *anal tube*, *anal sac*, or *anal series*, and it is designated the *first anal* (X). A plate that may be present to the right of X is termed the *right second anal* (RX) and one to the left is indicated as the *left second anal* (LX). Collectively, anal plates may be indicated as XX. In some crinoids there may be numerous XX in the dorsal cup, but in general these plates join others of the tegmen without sharp demarcation between them.

The simplest structure of the tegmen in crinoids consists of five interradially disposed plates called *orals* (sing. O, pl. OO). These surround the mouth, and their contiguous edges mark the position of food grooves (*ambulacra*). Most crinoids have a tegmen that is composed of many plates. In some types these plates are divisible into *ambulacrals* (sing. Amb, pl. AmbAmb) and *interambulacrals* (sing. IAmb, pl. IAmbAmb), but in other groups this differentiation is lacking. The tegmen may be distended in the form of a sac or tube that bears the anal vent, and accordingly this is known as the *anal sac* or *tube*. In some crinoids the anal vent is located in the dorsal cup or at the end of an armlike structure supported by the RA or sRA.

The various symbols and what they represent are listed below alphabetically for easy reference. Other symbols, not here listed, are discussed fully in a recent paper by Moore and Laudon (*JP* 15: 412–423, il, 1941).

SYMBOLS USED IN DESCRIBING CRINOIDS

(The first symbol is singular; the second plural.)

Amb,AmbAmb	Ambulacral(s)
AR	Anterior radial
Ax, AxAx	Axillary(ies)
B, BB	Basal(s)
Br, BrBr	Brachial(s)
fBr, fBrBr	Fixed brachial(s)
IAmb, IAmbAmb	Interambulacral(s)
IB, IBB	Infrabasal(s)
IBr, IBrBr	Interbrachial(s)
IR, IRR	Interradial(s)
iRA	Inferradianal
ISBr, ISBrBr	Intersecundibrachial(s)
ITBr, ITBrBr	Intertertibrachial(s)
LAR	Left anterior radial
LPR	Left posterior radial
LX	Left second anal
O, OO	Oral(s)
PB	Posterior basal
PBr, PBrBr	Primibrachial(s)
QBr, QBrBr	Quartibrachial(s)
R, RR	Radial(s)

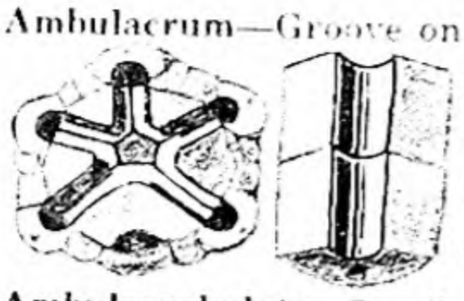
(178) **White, C. A.,** Contributions to paleontology — 6: *USGS* (*Hayden*), An Rp 12: 122–130, 160–163, il, 1880; (179) Fossils of the Indiana rocks: *Ind G S*, An Rp 10: 471–522, pl 1–11, 1881; (180) Fossils of Indiana rocks: Idem 11: 347–401, pls 37–55, 1882. (181) **Whiteaves, J. F.,** Fossils from Hamilton of Ontario: *CGS*, *Contr Can Pal* 1: 91–125, pl 12–16, 1889; (182) Fossils of Devonian rocks of Mackenzie River Basin: Idem: 107–253, pl 27–32, 1891. (183) **Whitfield, R. P.,** New crinoid from the Burlington limestone at Burlington, Iowa: *AMNH*, B 1: 7–9, il, 1881. (184) *Wis G S*, Pal 4: 160–363, pl 1–27, 1882; (185) Fauna of the Lower Carboniferous of Spergen Hill, Ind: *AMNH*, B 1: 39–97, il, 1882; (186) Fossils from the Coal Measures: *Ohio G S*, Rp 7: 407–693, pl 1–56, 1893; (187) New crinoid from Indiana: *AMNH*, B 13: 23, 24, il, 1900. (188) **Wood, E.,** Middle Devonic crinoids: *SMC* 47: 56–84, il, 1904; (189) Troost's unpublished manuscript on the crinoids of Tennessee: *USNM*, B 64: 1–150, pl 1–15, 1909. (190) **Worthen, A. H.,** Crinoids from the Lower Carboniferous and Coal Measures of Illinois-Iowa: *Ill St Mus N H*, B 1: 3–38, 1882; (191) Fossil invertebrates: *Ill G S* 7: 265–338, pl 27–30, 1883; (192) Fossil invertebrates: Idem 8: 68–154, pl 9–14, 17–27, 1890. (193) **Worthen, A. H.,** and **Meek, F. B.,** Paleontology of Illinois: *Ill G S* 5: 323–619, pl 1–23, 1873.

PLATE 52

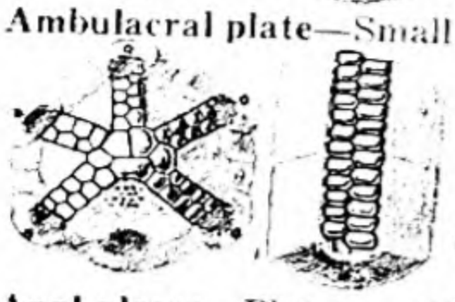
Analyses of representative crinoids of the orders Disparata and Cladoidea, subclass Inadunata.

TERMINOLOGY

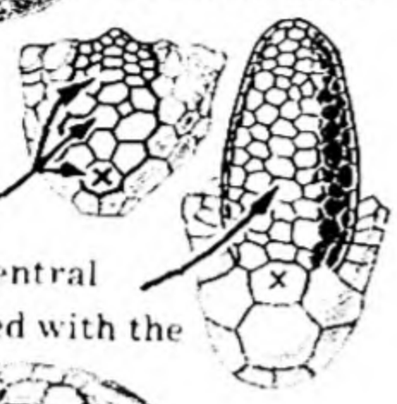
Ambulacrum—Groove on pinnule, arm, or tegmen that conducts water and food (plural, ambulacra).



Ambulacral plate—Small plate, covering part of ambulacral groove, designated **Amb** (pl. **AmbAmb**).



Anal plates—Plates of the posterior interray area, designated **XX**.



Anal sac or tube—Ventral structure associated with the anal vent.

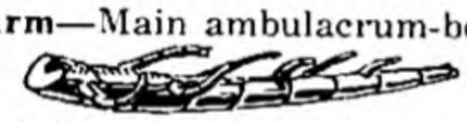
Anal vent—External termination of the digestive system.

Anal—Lowest plate, designated as **X**, in anal series, excluding radianal.

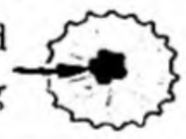
Anal series—All anal plates in dorsal cup.

Anterior—Side opposite anal interradius, designated **A**.

Arm—Main ambulacrum-bearing appendage.

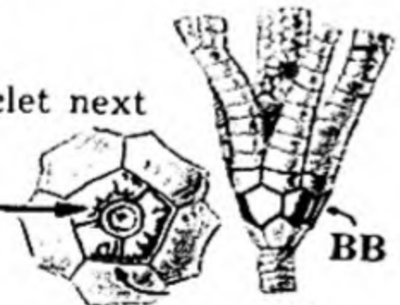


Axial canal—Central nerve and circulatory channel extending through column.



Axillary—Ray plate on which bifurcation takes place, designated **Ax** (plural **AxAx**).

Basal—Plate of circlet next below radials, designated **B** (plural **BB**).



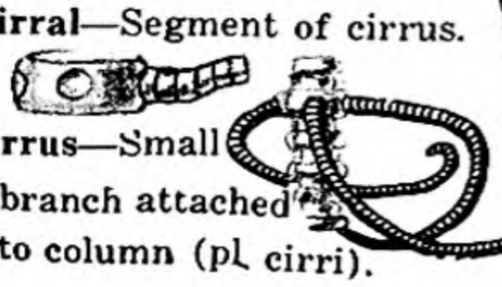
Biserial—Interlocking arrangement of arm segments in a double series.

Brachial—Any ray plate above radials (except in pinnules) both in dorsal cup and arms, designated **Br** (plural **BrBr**).

Calyx—Dorsal cup and ventral structures exclusive of free arms.

Cirral—Segment of cirrus.

Cirrus—Small branch attached to column (pl. cirri).

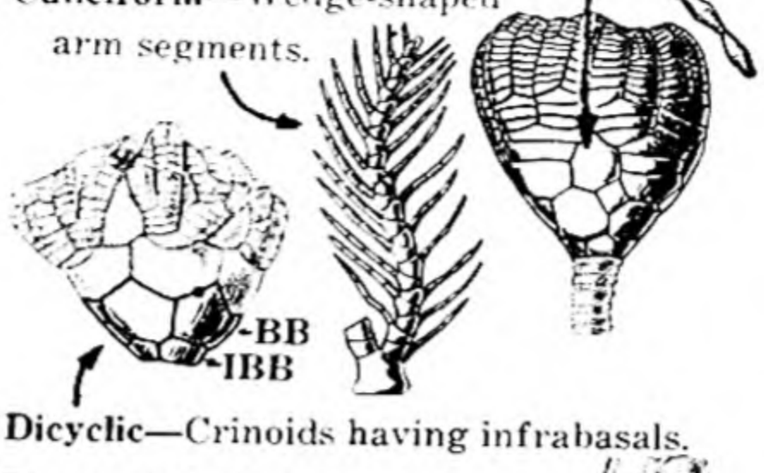


Column—Stem or stalk.

Columnal Segment of the column.

Crown—The calyx and arms.

Cuneiform—Wedge-shaped arm segments.



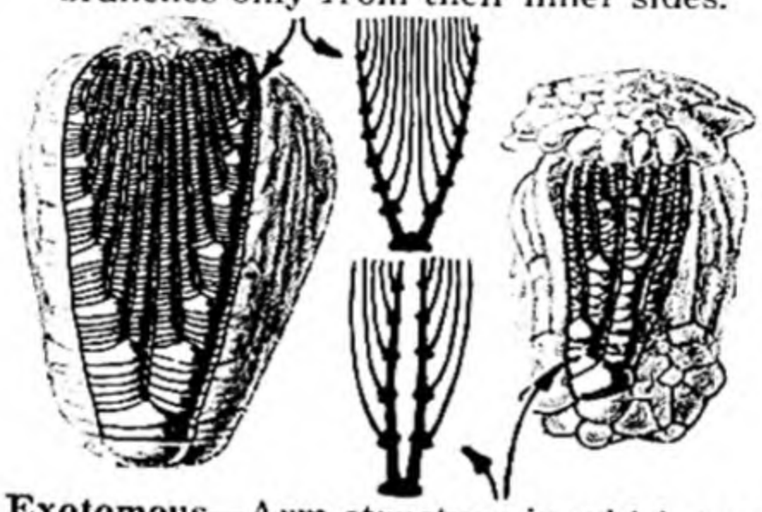
Dicyclic—Crinoids having infrabasals.

Distal—Direction away from center of base of dorsal cup.

Dorsal—Position occupied by dorsal cup.

Dorsal cup—Portion of calyx below free arms.

Endotomous—Arm structure in which two main arms give off branches only from their inner sides.



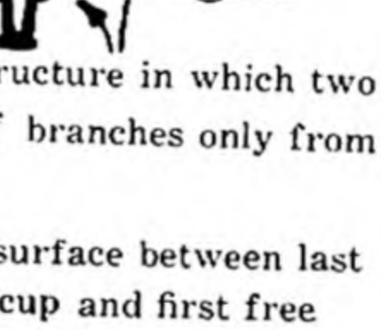
Exotomous—Arm structure in which two main arms give off branches only from their outer sides.

Facet—Articulating surface between last ray plate in dorsal cup and first free arm plate, or between free arm segments.

Heterotomous—Arm structure characterized by unequal branches.

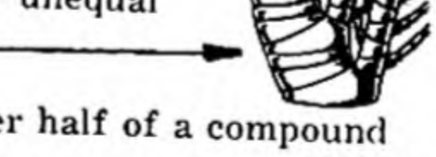
Inferradial—Lower half of a compound radial.

Infrabasal—Plate of lowest circlet in dicyclic crinoids, designated **IB** (pl. **IBB**).

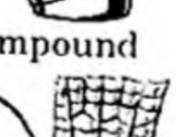


Interbrachial—Plate between brachials of different rays, designated **IBr** (plural, **IBrBr**).

Interradial—Plate (except anal) between two radials, designated **IR** (plural, **IRR**).

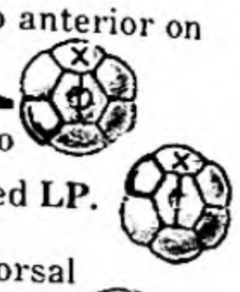


Isotomous—Arm structure characterized by equal branches.



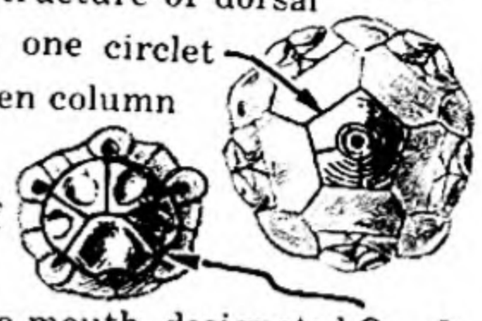
Left Anterior—Side next to anterior on left, designated **LA**.

Left Posterior—Side next to posterior on left, designated **LP**.

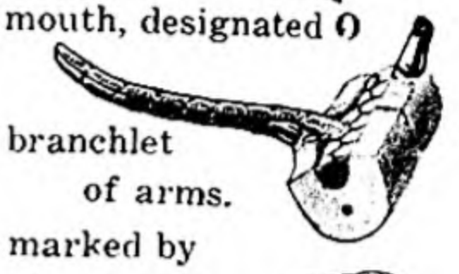


Monocyclic—Structure of dorsal cup in which one circlet occurs between column and radials.

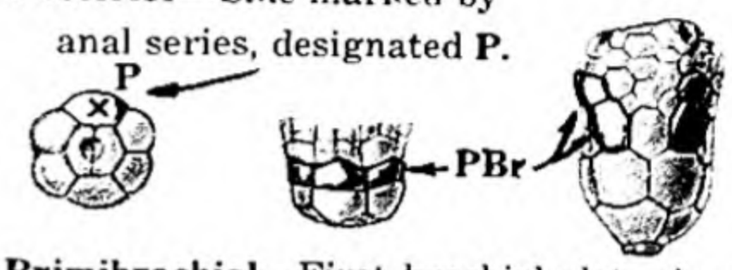
Oral—Plate of circlet that surrounds the mouth, designated **O** (plural, **OO**).



Pinnule—Small branchlet of arms.



Posterior—Side marked by anal series, designated **P**.



Primibrachial—First brachial plate above radial, designated **PBr** (plural, **PBrBr**).

Proximal—toward base of dorsal cup.

Radial—Lowermost plate of a ray, designated **R** (plural, **RR**).

Radianal—A plate of the anal series located directly or obliquely below the right posterior radial, designated **RA**.

Ray—Series of plates beginning with a radial and including the arm brachials.

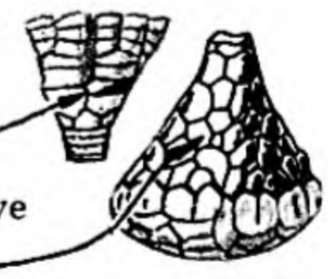
Right anterior—The side next to the anterior lying on the right, designated **RA** (always in combination, as **RAB, RAR**).

Right posterior—The side next to the posterior lying on the right, designated **RP**.

Secundibrachial—Brachial above first axillary up to and including the second axillary, designated **SBr** (plural, **SBrBr**).

Superradial—Upper half of a compound radial.

Tegmen—Cover above dorsal cup.



Tertibrachial—Brachial above the second axillary plate up to and including third axillary plate, designated **TBr** (plural, **TBrBr**).

Uniserial—Arm structure in which the brachials are in single series.

RA.....Radianal
RAR.....Right anterior radial
RPR.....Right posterior radial
RX.....Right second anal
SBr, SBrBr .....Secundibrachial(s)
sRA.....Superradianal
TBr, TBrBr.....Tertibrachial(s)
VBr, VBrBr.....Quintibrachial(s)
X.....First anal plate
XX.....Anal plates

The arms of crinoids are appendages of the calyx that are unbranched or branched and that generally are freely movable. They are attached at the summit of the dorsal cup. The upper or inner (*ventral*) side of the arms bears a food groove (*ambulacrum*) that is roofed by minute covering plates. Water carries the food particles along the ambulacra to the mouth, which may be located upon the tegmen or beneath it. Arm plates, or BrBr, may be arranged in a single series (*uniserial*) or in a double row of interlocking segments (*biserial*). Branching of the arms is designated as *isotomous* if the two divisions are subequal, and it is termed *heterotomous* if they are unequal. Branchlets are called *ramules* or *pinnules*.

The stem, or column, of crinoids consists of superposed plates that are generally circular or pentagonal in outline. The segments, which are called *columnals*, may be elliptical or have other shapes. The stem is perforated centrally by an axial canal of varying shape and size, and there may be peripheral canals. Articulating surfaces of the columnals permit some movement of the stem. Side branchlets, called *cirri* (sing. *cirrus*), may be borne by some stem segments, which are termed *nodals*, other columnals being classed as *internodals*. The base of the stem may bear rootlike branches or some other form of expansion, or it may dwindle to a point. Some crinoids, both fossil and Recent, are stemless in the adult stage.

Remains of crinoids are extraordinarily abundant in some formations, although it is generally more difficult to collect good specimens of this group of fossils than many other kinds. The complexity of structural organization in the hard parts of crinoids, however, gives play for almost endless evolutionary differentiation that is clearly discernible and that accordingly is valuable in serving the ends of stratigraphic paleontology. Most species of crinoids, and very many genera, have an extremely narrow vertical range, but many have a wide geographic distribution.

A satisfactory classification of crinoids, based on phylogenetic relations, is not yet possible, but notable progress toward such a classification has been made, especially by Wachsmuth and Springer (162, 163), Springer (128, 129, 131, 142), Bather (3), Jaekel (51), and Wanner (165–167). Morphologically most fundamental in the evolution of the crinoids seems to be the origin in very earliest Paleozoic time of a stock characterized by the presence of a single circlet of plates below the base of the rays and of another stock characterized by the occurrence of two circlets below the base of the rays. The monocyclic or dicyclic structure of the dorsal cup is one of the most stable features of clearly differentiated crinoid groups, such as the Flexibilia, as it is of the Blastoidea. The general content of the orders of crinoids, proposed by Bather, but not his binomial designations of them, is here accepted. Many of the family assemblages are revised. For a recent classification of Crinoidea see Moore, R. C., and Laudon, L. R., Classification and evolution of Paleozoic crinoids: *GSA*, SP46: 1—153, pl 1—14, 18 text figs, 1943.

An alphabetically arranged summary of terms that are most commonly used in the description of crinoids, accompanied by diagrammatic illustrations, is given under the heading "Terminology."

Subclass Inadunata

Order Disparata. Monocyclic crinoids having a dorsal cup composed only of BB, RR, and in some cases XX; arms free above RR. This order (equivalent to Bather's **Monocyclica Inadunata**) is characterized by arms that are freely movable above the RR and by the unequal development of structures in the different rays, including occurrence of compound RR or reduced size of some RR. It comprises most of the **Larviformia** and some of the **Fistulata,** as classified by Wachsmuth and Springer. **Ord.–Perm.**

IOCRINIDAE. Monocyclic; RR seemingly identical and not compound, but plate of this circlet of the RP ray is the iRA and succeeding Ax, which supports XX and PBrBr, is the sRA; XX in linear armlike series; column coiled in some genera and marked by abundant cirri that may conceal crown. **Ord.–Dev.**

IOCRINUS[1] Hall 1866 [52—15]

(**Heterocrinus crassus* Meek and Worthen). Cup truncate conical, moderately large; PBrBr three or more in each ray, arms round, branching isotomously; stem not coiled (162). **Ord.** (Mohawkian-Richmond).

***I. crassus** (M and W) [52—15, 53—2] (84, 162). **Maquoketa:** Ill.

I. subcrassus (Meek and Worthen) [53—10, 11] (84, 162). **Trenton–Richmond:** Ohio.

MYELODACTYLUS Hall 1852

(**M. convolutus*). Crown like *Iocrinus* but more slender; stem coiled, abundant long cirri generally concealing crown (140). **Sil., Dev.**

***M. convolutus** (Hall) [54—26] (140). **Sil.:** N. Y. (Clinton), Ohio (Brassfield), Ind. (Laurel), Ill. (Racine).

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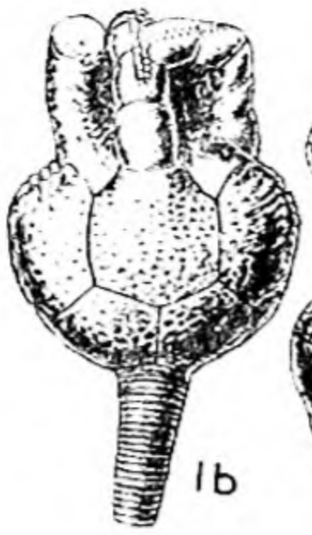
[1] No synonyms of crinoid genera are listed because they are treated fully in the works by Bassler and Moodey (1943) and Moore and Laudon (1943) cited above.

1a


1b

1c

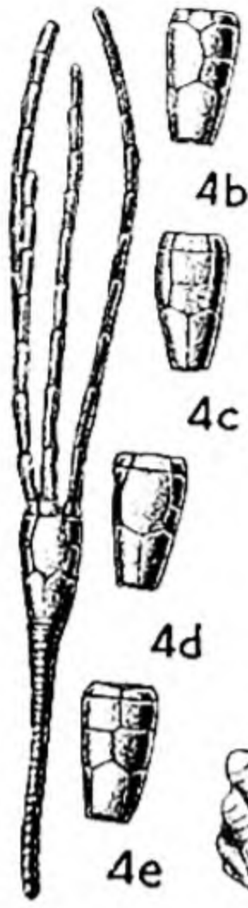
1d

2a

2b

3a

3b

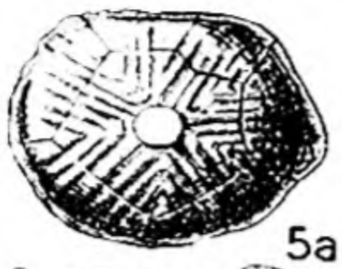

4a

4b

4c

4d

4e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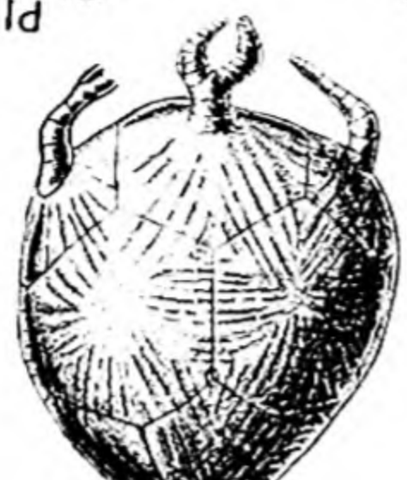
5b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7

8a

8b

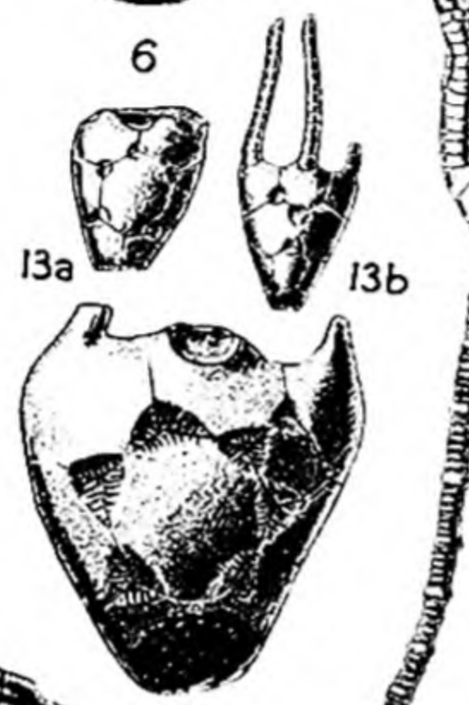
9

10a

10b

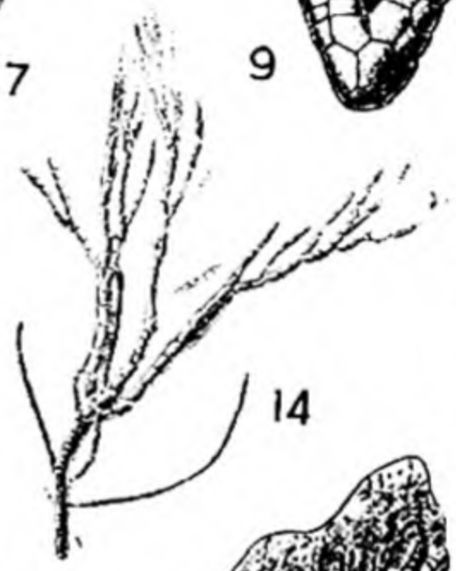
11

12


13a

13b

13c


14

15a

15b

16

17

18

19a

19b

20a

20b

21

24

20c

22a

22b

23

25a

25b

26a

26b

M. keyserensis Springer [54—27] (140). **Sil.:** W. Va. (Keyser).

M. nodosarius (Hall) [54—25] (140). **Dev.:** N. Y. (New Scotland).

Other genus: *Ammonicrinus* Springer (140).

HOMOCRINIDAE. Monocyclic; small steeply conical cups; BB 5; RR 4, LAR and RAR compound; right posterior ray plates of cup comprise iRA and sRA; X partly in cup, followed above by XX in series; arms long, simple, variously branched, PBrBr two or more. **Ord., Sil.**

HOMOCRINUS Hall 1852 [52—7]

(**H. parvus*). Arms five, simple, unbranched (36, 54). **Sil.** (Niagaran).

***H. parvus** Hall [52—7, 53—4] (64). **Clinton:** N. Y.

DAEDALOCRINUS Ulrich 1924 [52—7]

(**D. kirki*). PBrBr two to four, arms slender, branching endotomously; sac balloonlike; column pentagonal proximally, round distally (157). **Ord.** (Mohawkian).

***D. kirki** Ulrich [52—7] (157). **Trenton:** Ont.

ECTENOCRINUS S. A. Miller 1889 [52—7]

(**Heterocrinus simplex* Hall). Cup very steep-sided, taper continuing on stem; LPR and AR squarely truncate below; PBrBr two in each ray, 10 main arms give off branchlets on alternate sides; stem round, tripartite (157). **Ord.** (Mohawkian, Cincinnatian).

***E. simplex** (Hall) [52—7, 53—8] (157). **Eden:** Ohio.

DRYMOCRINUS Ulrich 1924 [52—7]

(**Heterocrinus geniculatus*). Like *Ectenocrinus* but arms geniculate; abundant long slender cirri (157). **Crd.** (Cincinnatian).

***D. geniculatus** (Ulrich) [52—7] (157). **Eden:** Ohio.

SYGCAULOCRINUS Ulrich 1924 [52—7]

(**S. typus*). Proximal stem segments much enlarged; PBrBr two in each ray, arm branches more widely spaced than in *Ectenocrinus* (157). **Ord.** (Richmond).

***S. typus** Ulrich [52—7] (157). **Wykoff:** Ia.

CALCEOCRINIDAE. Monocyclic; crown bent on stem; BB three or four, connected by muscular articulation with RR; LPR and AR simple, other RR compound; anal tube on side toward stem; arms uniserial, that on LAR unbranched, others branched. **Ord.–L. Carb.**

CREMACRINUS Ulrich 1886

(**C. punctatus*). BB four, all touching stem, which is at right of anal tube; median and three lateral arm-bearing rays, PBrAx equal-faced but branches heterotomous (142). **Ord., Sil.**

C. articulosus (Billings) [55—8]. Arm of RAR shows incipient dwarfing; two main rami of lateral arms show five to seven heterotomous branches (142). **Ord.** (Mohawkian): Ont.; Ky. (Trenton).

C. tubuliferus Springer [55—7]. Distinguished mainly by its very large curved anal tube (142). **Sil.:** Tenn. (Beech River).

EUCHEIROCRINUS Meek and Worthen 1869

(**Cheirocrinus chrysalis* Hall). Like *Cremacrinus* but differs in having only a median and two lateral arm-bearing rays; stem in plane of anal tube (142). **Sil.** (Niagaran).

***E. chrysalis** (Hall) [55—6] (142). **Rochester:** N. Y.

DELTACRINUS Ulrich 1886

(**Cheirocrinus clarus* Hall). Differs from *Eucheirocrinus* in having only three BB, of which two touch stem; inferRR separated by subanal plate (142). **Dev.**

***D. clarus** (Hall) [57—8] (25). **Hamilton:** N. Y.

CALCEOCRINUS Hall 1852

(**C. halli* Ringueberg) Like *Deltacrinus* but differs in the strongly heterotomous branching of lateral arms, main AxAx forming a continuous series, arching toward anal tube (142). **Sil.** (Niagaran).

C. bassleri Springer [55—15]. Large species distinguished by exposure of main branch of axil-arms, short columnals, and relatively weak anal tube (142). **Beech River:** Tenn.

HALYSIOCRINUS Ulrich 1886

(**Cheirocrinus dactylus* Hall). Like *Calceocrinus* but inferR and iRA meet under X and median arm commonly branched (142). **Dev., Miss.**

***H. dactylus** (Hall) [55—5]. Distinguished by arm

PLATE 53

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name will be found in the references under Crinoidea.]

1a–d. Hybocystites eldonensis (127) (x2). Left ant., ant., post., ventral. **2a, b. Iocrinus crassus** (83), type. Post. and ant. views. **3a, b. Hybocrinus tumidus** (127). Post., ventral. **4a–e. Homocrinus parvus** (54). Crown (x3), post. (x4), left ant. (x4), ant. (x4), right post. (x4). **5a, b. Carabocrinus radiatus** (14), type. Dorsal, post. **6. Carabocrinus vancortlandti** (14), type. Ant. **7. Cupulocrinus humilis** (128). Right ant. **8a, b. Ectenocrinus simplex** (81). Lat., post. **9. Cupulocrinus heterocostalis** (127), type. Post. **10a, b. Iocrinus subcrassus** (81). Lat., post. **11. Iocrinus subcrassus** (83). Lat. **12. Cupulocrinus jewetti** (127). Post. **13a–c. Porocrinus conicus** (14). Ant., ant., post. (x2.5). **14. Lasiocrinus expressus** (74) (x2), type. Ant. **15a, b. Lasiocrinus scoparius** (54) (x2), type. Post., ant. **16. Merocrinus typus** (164), type. Post. **17. Merocrinus corroboratus** (164), type. Post. **18. Cradeocrinus elongatus** (25), type. Left anterolateral. **19a, b. Palaeocrinus striatus** (50) (x3), type. Right post., ant. **20a–c. Lecythiocrinus adamsi** (191), type. Lat., post., ventral. **21. Lecythiocrinus olliculaeformis** (178) (x1.5), type. **22a, b. Hybocrinus conicus** (127). Post., ventral. **23. Ottawacrinus billingsi** (127) (x2), type. Left post. showing large ventral sac. **24. Ottawacrinus typus** (127) (x2), type. Post. **25a, b. Cupulocrinus humilis** (127). Post., ant. **26a, b. Anomalocrinus incurvus** (81). Ant., post.

1a 1b 1c 2a 2b 2c 2d

3b 3c 3a 4a 5a

6a 6b 6c 7 10 4b 5b

8 9a 14e 9b 12b

14a 14b 14c 14d 11 12a

15a 15b 15c 15d 20a 13a 21a 21b

16a 16b 16c 20b 20c 13b 22

17a 17b 17c 17d

18a 18b 18c 24a 24b 24c 23a 23b

19 25 23c 30

28 27 26 29 31a 31b

Ampheristocrinus

branching and moderately small size (142). **Miss.:** Ia. (Burlington).

H. nodosus (Hall) [55—9]. Differs from *H. dactylus* in its large size, nodosity, curvature, and frequent branching of median arm (142). **Miss.:** Ind. (Keokuk).

PISOCRINIDAE. Monocyclic; BB three to five; RR five, LPR and AR much larger than others; iRA large, occurring below sRA and RAR; arms five, uniserial. **Sil., Dev.**

PISOCRINUS Koninck 1858 [54—19]

(**P. pilula*). BB five, unequal; processes at upper angles of RR make partitions between arm bases; anal tube resembles arm; stem round (142). **M. Sil.** (N. America; Europe; Australia).

P. baccula Miller and Gurley [54—17]. Relatively large globose cup; BB form broad triangular concave base (142). **Laurel:** Ind.

P. gemmiformis S. A. Miller [54—14]. A small species having low narrow processes between facets and prominent BB (142). **Niagaran:** Ind. (Laurel), Tenn. (Osgood, Laurel), Ill. (Racine), Mo. (Bainbridge).

P. quinquelobus Bather [54—15]. Distinguished by large deeply undercut spearhead processes at upper RR angles (142). **Niagaran:** Tenn. (Brownsport), Ill. (Racine), Mo. (Bainbridge).

P. sphericus Rowley [54—16]. Resembles *P. quinquelobus* but distinguished by globose shape (142). **Niagaran:** Tenn. (Brownsport), Mo. (Bainbridge).

P. tennesseensis (Roemer) [54—18]. Largest known species; cup wide conical, large stem facet (142). **Niagaran:** Tenn. (Dixon, Brownsport), Mo. (Bainbridge).

ZOPHOCRINIDAE. Monocyclic; small conical or pyriform cup; BB three; RR four slightly unequal, directly supporting 15 or more PBrBr; no RA or X recognized; OO five (89). **Sil., Dev.**

ZOPHOCRINUS S. A. Miller 1891

(**Z. howardi*). Calyx elongate pyriform (142). **M. Sil.** (N. America only).

***Z. howardi** S. A. Miller [54—20] (142). **Niagaran:** Ind. (Laurel), Tenn. (Beech River).

Other genera: *?Hypsocrinus* Springer and Slocom (143), *?Perissocrinus* Goldring (30).

HAPLOCRINITIDAE. Monocyclic; BB five; RR four, bearing processes at edges of facets, LAR and RAR compound; iRA directly below sRA, occupying right posterior ray; tegmen composed of OO only; arms five, unbranched, uniserial. **Dev.**

HAPLOCRINITES Steininger 1834 [52—2]

(**H. sphaeroideus*). Characters of family (162). **M. Dev.** (N. America; Europe).

H. clio (Hall) [56—14] (25). **Marcellus:** N. Y.

ANAMESOCRINIDAE. Monocyclic; calyx small; cup structure as in Haplocrinitidae; small X followed by armlike tube; several threadlike arms borne by each R; stem round. **Dev.** (N. America only).

ANAMESOCRINUS Goldring 1923 [52—1]

(**A. lutheri* Goldring [56—12] (25), from **Laona** of N. Y.). Characters of family (25). **U. Dev.**

ALLAGECRINIDAE. Monocyclic; small, mostly asymmetrical cups; RR four, each bearing one or more facets; arms slender, unbranched, uniserial; RA occupies position of RPR, X on its left shoulder, supporting armlike tube but not entering cup in some genera. **Dev.–Perm.** (worldwide).

HYBOCHILOCRINUS J. M. Weller 1930

(**Allagecrinus americanus* Rowley). BB three or fused; RR elongate; left shoulder of RA notched for placement of X; tegmen consists of OO; stem round (169). **U. Dev., Miss.**

***H. americanus** (Rowley) [56—2]. Very small (169). **U. Dev.:** Mo. (Louisiana).

H. rowleyi (Peck) [56—1]. Calyx less slender than *H. americanus* (116). **Miss.:** Mo. (Chouteau).

KALLIMORPHOCRINUS

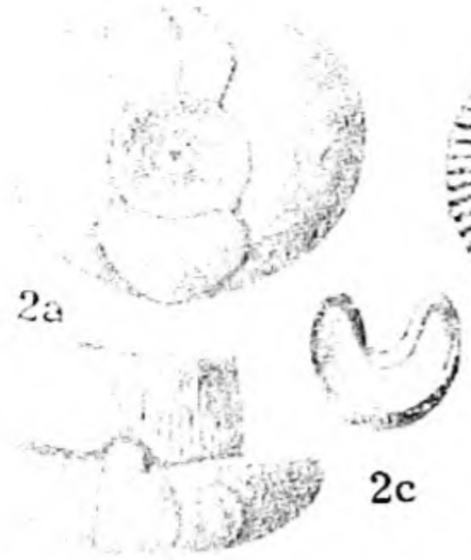
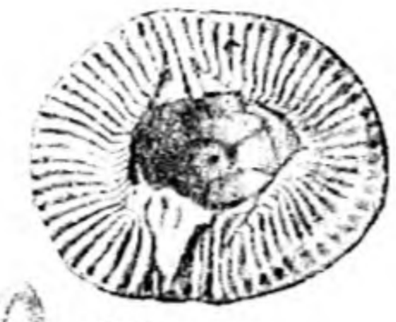
J. M. Weller 1930 [52—4]

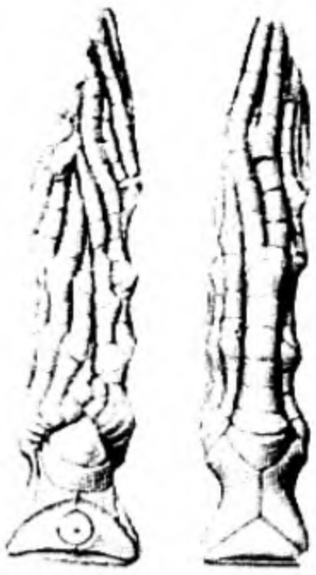
(**K. astrus*). Like *Hypochilocrinus* except that no facet for attachment of X is present (105, 169). **Miss.–Perm.**

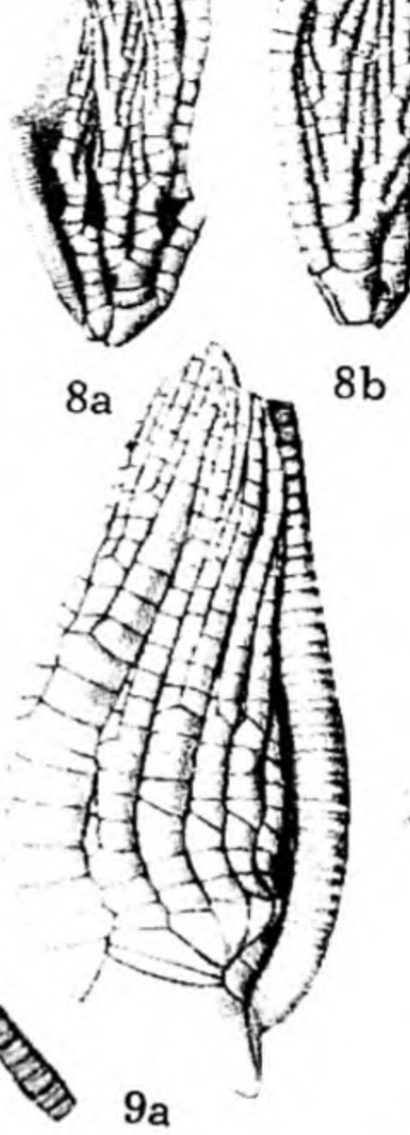
PLATE 54

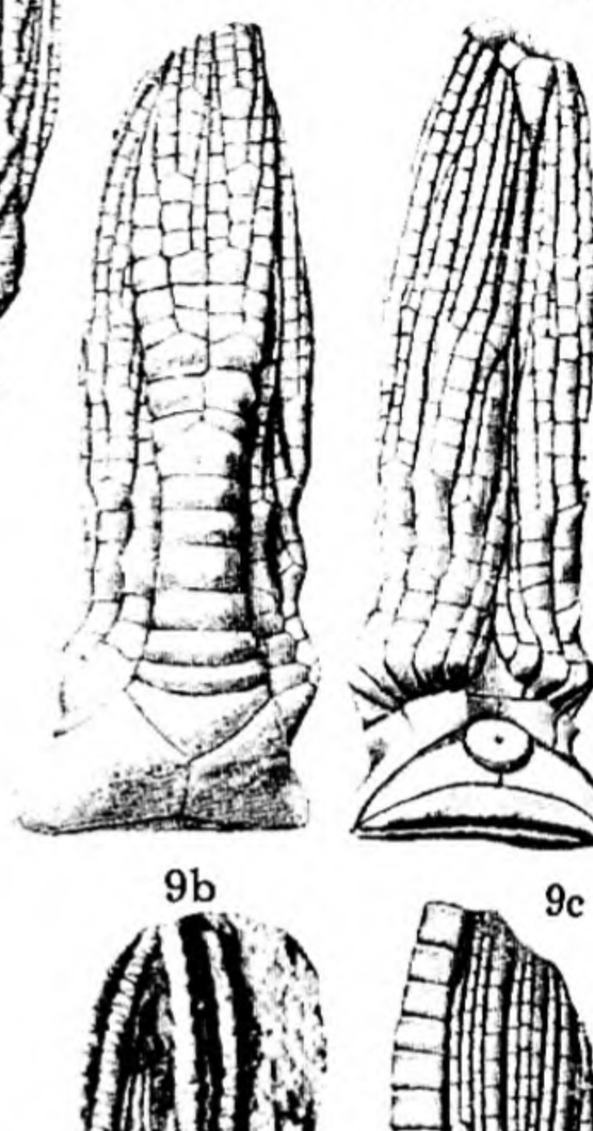
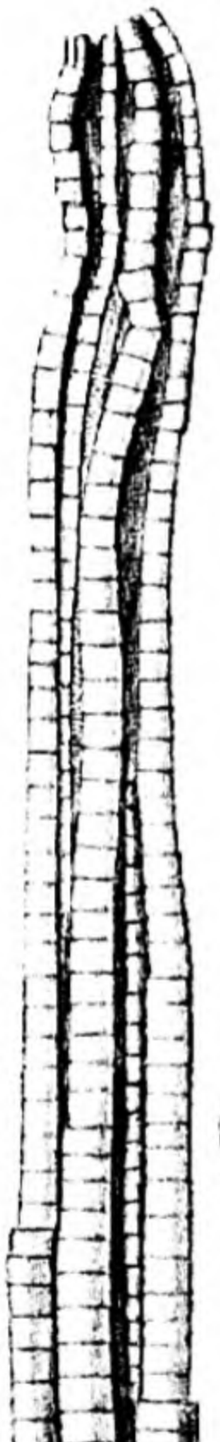
[Figures are x1 unless otherwise indicated; all figures after Springer (142).]

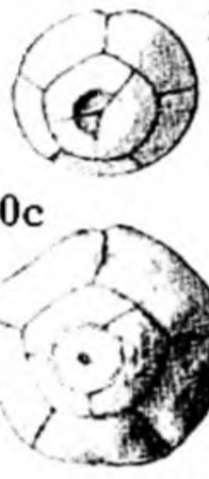
1, 2. Lecanocrinus spp. 1a–c. L. pusillus. Dorsal (x2), crown and stem, post. (x2). **2a–d. L. pisiformis** (x2). Post., ant., ventral showing arms, ventral. **3a–c. Clidochirus americanus.** Post., ant., right post. **4a, b. Pycnosaccus patei.** Right ant., post. **5a, b. Ichthyocrinus subangularis.** Right post. interradius, oblique dorsal. **6a–c. Hormocrinus tennesseensis.** Dorsal (x2), right post., left ant. **7, 8. Anisocrinus spp. 7. A. oswegoensis,** type. Post. **8. A. greenei,** type. Right post. **9a, b. Asaphocrinus bassleri,** type. Post., ant. **10, 11. Sagenocrinites spp. 10. S. clarki,** restoration of type. Post. **11. S. americanus,** type. Post. **12a, b. Gnorimocrinus cirrifer.** Dorsal (x2), post. **13a, b. Prataxocrinus robustus,** type. Post., ant. **14–19. Pisocrinus spp. 14a–e. P. gemmiformis.** Dorsal (x2), left post. (x2), iRA (x2), ventral (x2), ventral (x4). **15a–d. P. quinquelobus** (x2). Dorsal, left ant., left ant., ventral. **16a–c. P. sphericus** (x2). Ant., ant., ventral. **17a–d. P. baccula** (x2). Dorsal, iRA, left ant., ventral. **18a–c. P. tennesseensis** (x2). Ant., ventral, dorsal. **19. Pisocrinus,** generic diagram (RR black, iRA cross-ruled). **20a–c. Zophocrinus howardi.** Tegmen, composed of two specimens (x6); dorsal (x2), lat. (x2). **21a, b. Cyathocrinites wilsoni** (x1.5). Post., right ant. **22. Botryocrinus polyxo.** Post. **23a–c. Mysticocrinus wilsoni** (x4), type. Post., ant., dorsal. **24a–c. Thalamocrinus ovatus** (x2). Ventral, dorsal, post. **25–27. Myelodactylus spp. 25. M. nodosarius,** type. Cirri and terminal of stem. **26. M. convolutus.** Coiled stem with cirri in place. **27. M. keyserensis.** Ant. **28. Ampheristocrinus typus.** Complete crown. **29. Ampheristocrinus,** generic diagram (RR black, XX stippled, RA cross-ruled). **30. Crotalocrinites cora.** "Cast" from external mold with brachials inside radial facet. **31a, b. Petalocrinus mirabilis.** Arm fans, ventral, dorsal.

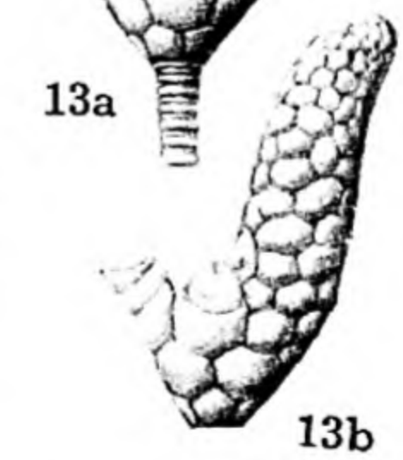
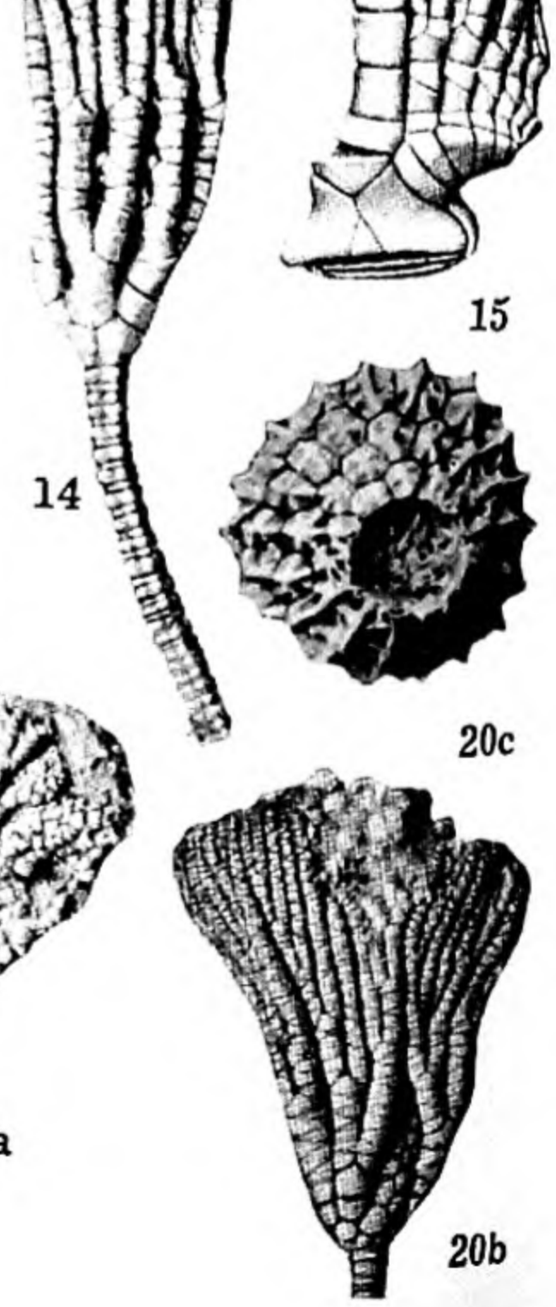









K. puteatus (Peck) [**56**—6]. Distinguished by shape of cup and ornamentation (116). **Miss.:** Mo. (Fern Glen).

***K. astrus** Weller [**56**—3]. Calyx star-shaped in ventral or dorsal view (169). **L. Penn.** (Des Moines): Ind.

K. indianensis Weller [**56**—5]. Differs from *K. astrus* in shape of cup (169). **L. Penn.** (Des Moines): Ind.

K. expansus Weller [**56**—4]. Cup expanded (169). **L. Penn.** (Des Moines): Ill.

TROPHOCRINUS Kirk 1930

(**T. tumidus*). Distinguished by pouchlike expansion on upper parts of LAR and LPR (59). **L. Miss.** (Kinderhook).

***T. tumidus** Kirk [**56**—11] (59). **Welden:** Okla.

ALLAGECRINUS

Carpenter and Etheridge 1881 [**52**—4]

(**A. austinii*). Cups truncate cone- to star-shaped; BB three or fused; RR unequal, LAR and RA each bearing only one arm but others may have two or more (105). **L. Carb.** (Europe)–**Perm.**

A. dignatus Moore [**56**—10]. Cup stelliform, RR pear-shaped (105). **L. Penn.** (Des. Moines): Okla. (Oologah).

A. strimplei Kirk [**56**—8]. Small, arms five to nine in adults (62). **Penn.** (Missouri): Okla. (Dewey).

A. bassleri Strimple [**56**—9]. Cup relatively large, lobate, arms to 14 in adult, some very slender (144). **Penn.** (Missouri): Okla. (Wann).

ALLOCATILLOCRINUS Wanner 1937 [**52**—4]

(**Catillocrinus carpenteri* Wachsmuth). Differs from *Catillocrinus* in having several arms on RAR, and X on depressed shoulder of RA instead of a raised process (105, 167). **Miss., Penn.**

***A. carpenteri** (Wachsmuth) [**55**—4]. Cup small, truncate cone-shaped; anal tube very long and slender, armlike; arms 13 to 24 (136). **Chester:** Ind., Ill., Ala.

A. rotundus Moore [**56**—19]. Cup round bowl-shaped; arms of LAR and RA robust, others very slender, total up to 42, most numerous on LPR and AR (105). **Penn.** (Morrow): Okla. (Brentwood).

A. morrowensis Strimple [**56**—18]. Differs from *A. rotundus* in the subtriangular outline of cup and in having most numerous arms on RAR and AR (147). **Penn.** (Morrow): Okla. (Wapanucka).

CATILLOCRINUS Shumard 1866 [52–4]

(**C. tennesseae*). Cup relatively large, low bowl-shaped; BB five; RR four, massive, very unequal, LPR and AR each bearing many slender unbranched arms, other RR and RA one-armed; X on raised process of RA, followed by thick crescentic plates of tall anal tube; stem round, tapering (105, 136). **Miss.** (Osage).

C. wachsmuthi Meek and Worthen [**55**—1]. Cup small, truncate cone-shaped; arms 24 to 39 (136). **Burlington:** Ia.

***C. tennesseeae** Shumard [**55**—2]. Largest known species; arms very numerous, up to 58 (136). **Keokuk:** Ky., Tenn.

EUCATILLOCRINUS Springer 1923

(**Catillocrinus bradleyi* Meek and Worthen). Differs from *Catillocrinus* in absence of a raised process on RA for attachment of X; anal tube long and slender (136, 167). **Miss.** (Osage).

***E. bradleyi** (M and W) [**55**—3]. Arms 40 to 46 (136). **Keokuk:** Ind.

HETEROCRINIDAE. Differ from Homocrinidae chiefly in that RAR is not compound. **Ord.** (Mohawkian–Richmond).

HETEROCRINUS Hall 1847 [**52**—11]

(**H. heterodactylus*). Isotomous branches on PBr_{3-5}, heterotomous branches on SBr_{3-5}, TBr_{4-6} and higher; stem pentagonal proximally, round distally (157, 162). **Ord.** (Mohawkian–Richmond).

***H. heterodactylus** Hall [**52**—11] (81, 157). **U. Ord.:** N. Y. (Lorraine), Ohio (Eden).

ISOTOMOCRINUS Ulrich 1924 [**52**—11]

(**I. typus*). Like *Heterocrinus* except that arms are more strongly articulated with RR and divide isotomously (157). **Ord.** (Mohawkian).

***I. typus** Ulrich [**52**—11] (157). **Trenton:** Ont.

DYSTACTOCRINUS Ulrich 1924 [**52**—11]

(**Heterocrinus constrictus* Hall). $PBrBr_1$ joined rigidly to RR, weak articulation with $PBrBr_2$; each ray has two main arms that give off isotomously branching armlets (157). **Ord.** (Cincinnatian).

***D. constrictus** (Hall) [**52**—11] (157). **Fairview:** Ohio.

Other genera: *Atyphocrinus* Ulrich (157), *Columbi-*

PLATE 55

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1, 2. Catillocrinus spp. 1. C. wachsmuthi (136). Right ant. **2a–d. C. tennesseeae** (136). Dorsal, post., proximal view of sac plate, ventral. **3. Eucatillocrinus bradleyi** (136). Right post. showing long anal sac. **4a–c. Allocatillocrinus carpenteri** (136). Post. showing long slender sac (x1.5); type from ant. side; right ant. (x1.5). **5a–c. Halysiocrinus dactylus** (142). Ant., post., left ant. **6a–c. Eucheirocrinus chrysalis** (142). Post. and left ant. views of type; ant. view of another specimen. **7, 8. Cremacrinus spp. 7. C. tubuliferus** (142) (x2). Ant. **8a, b. C. articulosus** (142). Ant., left post. **9a–c. Halysiocrinus nodosus** (142). Left post., left ant., post. **10, 11. Synbathocrinus spp. 10a–c. S. wachsmuthi** (136). Ventral (x1.5), post. of crown, dorsal (x1.5). **11a, b. S. robustus** (136). Dorsal, ventral. **12a, b. Glassocrinus lyoni** (142), type. Dorsal, post. **13a, b. Parisocrinus siluricus** (142), type (x1.5). Ant., left post. showing massive sac. **14. Ascetocrinus rusticellus** (140). Left ant. **15. Calceocrinus bassleri** (142). Left post. **16. Synbathocrinus dentatus** (136). Post. **17. Ascetocrinus scoparius** (140). Left ant. showing recurved sac. **18a–d. Coeliocrinus dilatatus** (140). Post., ant., left ant. (type), right post. (type). **19. Pelecocrinus aqualis** (140). Post. **20a–c. Coeliocrinus ventricosus** (140). Ant. (type), post., proximal view of sac.

1a
1b
2a
2b
3a
3b
3c
4a
4b
5
6a
6b
7a
7b
8a
8b-e
9a
9b-e
10a-d
11a
11b
12
13a
13b
13c
13d
14a
14b
14c
15a
15b
15c
16a
16b
16c
17
18a
18b
18c
19a
19b
19c
20
21
22
23
24a
24b
24c
25a
25b
26a
26b
26c
27
28a
28b
29
30
31a
31b
32

crinus Ulrich (157), *Lichenocrinus* Hall (81), *Ohiocrinus* Wachsmuth and Springer (157).

SYNBATHOCRINIDAE. Crown slender, subcylindrical; cup monocyclic; RR four, facets broad; RA in position of RPR, X partly entering cup; arms five, unbranched, uniserial, nonpinnulate. **Dev.–Perm.**

SYNBATHOCRINUS Phillips 1836 [52—10]

(**S. conicus*). BB three, small plate in LA interray (136, 162). **Dev., Miss.**

S. sulcatus Goldring [56—17]. Cup conical, BB low, RR projecting; BrBr angular (25). **Onondaga:** N. Y.

S. matutinus Hall [56—22]. Cup relatively low; arms long and very slender (25). **Hamilton:** Ia.

S. dentatus Owen and Shumard [55—16]. Cup high conical; PBr_1 about equal to RR (136). **Miss.** (Osage): Ia. (Burlington), Mo. (Fern Glen).

S. wachsmuthi Meek and Worthen [55—10]. RR less projecting than in *S. sulcatus* (136). **Burlington:** Ia. (Burlington).

S. robustus Shumard [55—11, 56—23]. Unusually large species (136). **Keokuk:** Ky., Tenn., Ill.

Other genus: *Phimocrinus* Schultze 1866 (136).

ANOMALOCRINIDAE. Monocyclic; cup structure as in the Heterocrinidae, but R facets narrow, arms round, uniserial, branching irregularly. **Ord.**

ANOMALOCRINUS

Meek and Worthen 1865 [52—8]

(**A. incurvus*). Calyx bowl-shaped; some abnormal specimens have a vertically bisected R (162). **Ord.** (Cincinnatian).

***A. incurvus** M and W [53—26]. The only described species (81). **Maysville:** Ohio.

Other genera: *Geraocrinus* Ulrich 1924 (157), *Glaucocrinus* Parks and Alcock 1912 (114).

HYBOCRINIDAE. Monocyclic; BB five, RR five, large, except RPR; RA nearly equal in size to RR, supporting X obliquely at left; anal sac absent; OO large; arms uniserial, unbranched. **Ord.** (Chazyan, Mohawkian).

HYBOCRINUS Billings 1857 [52—3]

(**H. conicus*). Arms five, regular, ambulacra not extending onto dorsal cup; anal opening simple or through valvular pyramid (127). **Ord.** (Mohawkian).

H. tumidus Billings [53—3]. Cup bowl-shaped; X elevated and having an arched crenulated border, anal vent through a pyramid (127). **Trenton:** Ont.; Ky.

***H. conicus** Billings [53—22]. Cup conical; X not elevated, anal vent not through pyramid (127). **Trenton:** Ont.; Ky.

HYBOCYSTITES Wetherby 1880 [52—3]

(**H. problematicus*). Like *Hybocrinus* except that only three RR bear free arms; ambulacral furrows extending from ventral to dorsal side of arms and across surfaces of armless RR onto BB (127). **Ord.** (Mohawkian).

H. eldonensis (Parks) [53—1]. Smaller than *H. problematicus* and ambulacral furrows extend less far on dorsal cup (127). **Trenton:** Ont.; Ky.

Order Cladoidea. Dicyclic crinoids having the arms free above the radials, plates of cup joined together firmly; mouth subtegminal. **Ord.–Trias.**

Suborder Cyathocrinoidea. Cladoidea having a bowl-shaped to globose cup and stout, relatively simple tegmen, OO well defined; anal sac mostly lacking but well developed in some genera; radial facets horseshoe-shaped; arms rounded, uniserial, typically branching several times isotomously. nonpinnulate. **Ord.–Perm.**

CARABOCRINIDAE. Dicyclic; cup conical to bowl-shaped; iRA below sRA, which lies directly or obliquely below RPR, X in line with RR; tegmen strong, OO rather large, no distinct anal sac; arms short and stout, simple or branching isotomously; stem round. **Ord., Sil.**

CARABOCRINUS Billings 1857 [52—19]

(**C. radiatus*). The sRA completely separating BB, iRA below it touching IBB, X in line with RR; arms branching (162). **Ord.** (Chazyan, Mohawkian).

PLATE 56

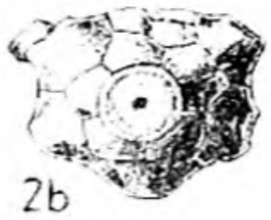
[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1, 2. Hybochilocrinus spp. 1a, b. H. rowleyi (116) (x28), type. Ventral, post. **2a, b. H. americanus** (169) (x15). Ventral, right post. **3–6. Kallimorphocrinus spp. 3a–c. K. astrus** (169) (x15), type. Lat., ventral, dorsal. **4a, b. K. expansus** (169) (x15), type. Dorsal, lat. **5. K. indianensis** (169) (x15), type. Lat. **6a, b. K. puteatus** (116) (x28), type. Post., ventral. **7a, b. Dichostreblocrinus scrobiculus** (160) (x15), type. Ventral, post. **8–10. Allagecrinus spp. 8a–e. A. strimpiei** (62, 105). Crown (x2.3); ventral, ant., post., dorsal, all x3.5. **9a–e. A. bassleri** (105). Left post. (type) (x3); ventral, post., ant., dorsal, all x3.5. **10a–d. A. dignatus** (105) (x3.5), type. Ventral, post., ant., dorsal. **11a, b. Trophocrinus tumidus** (59) (x12.5). Ventral, ant. **12. Anamesocrinus lutheri** (25) (x2), type. Left anterolateral. **13a–d. Cibolocrinus punctatus** (108), type. Ventral showing distinctive articular facets and displaced arms, dorsal, post., ant. **14a–c. Haplocrinites elio** (25) (x6), type. Ventral, ant., dorsal. **15, 16. Cibolocrinus spp. 15a–c. C. tumidus** (107), type. Post., dorsal, ventral. **16a–c. C. typus** (108), type. Post., dorsal, ventral. **17. Synbathocrinus sulcatus** (25) (x2), type. Ant. **18, 19. Allocatillocrinus spp. 18a–c. A. morrowensis** (147) (x2), type. Ventral, post., dorsal. **19a–c. A. rotundus** (105) (x2), type. Post, dorsal, ventral. **20. Synerocrinus formosus** (108), type. Post. interradius at right. **21. Apographiocrinus typicalis** (108), type. Ant. **22, 23. Synbathocrinus spp. 22. S. matutinus** (25), type. Lat. **23. S. robustus** (85). **24, 25. Oklahomacrinus spp. 24a–c. O. supinus** (103), type. Dorsal, ventral, post. **25a, b. O. loeblichi** (103), type. Oblique view of crown showing pendent arms, x1.5; dorsal (x2). **26–28. Ulocrinus spp. 26a–c. U. kansasensis** (91), type. Ventral, post., dorsal. **27. U. buttsi** (91), type. Post. **28a, b. U. sangamonensis** (82), type. Post., dorsal. **29. Cibolocrinus banioni** (103), type. Dorsal. **30. Talanterocrinus mcguirei** (103), type. Dorsal. **31a, b. Paragassizocrinus tarri** (108). Left post., ant. **32. Aesiocrinus magnificus** (92), type. Left post. view of crown showing typical arms and sac.

1a

1b

2a


2b

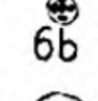
3a

3b

4

5a

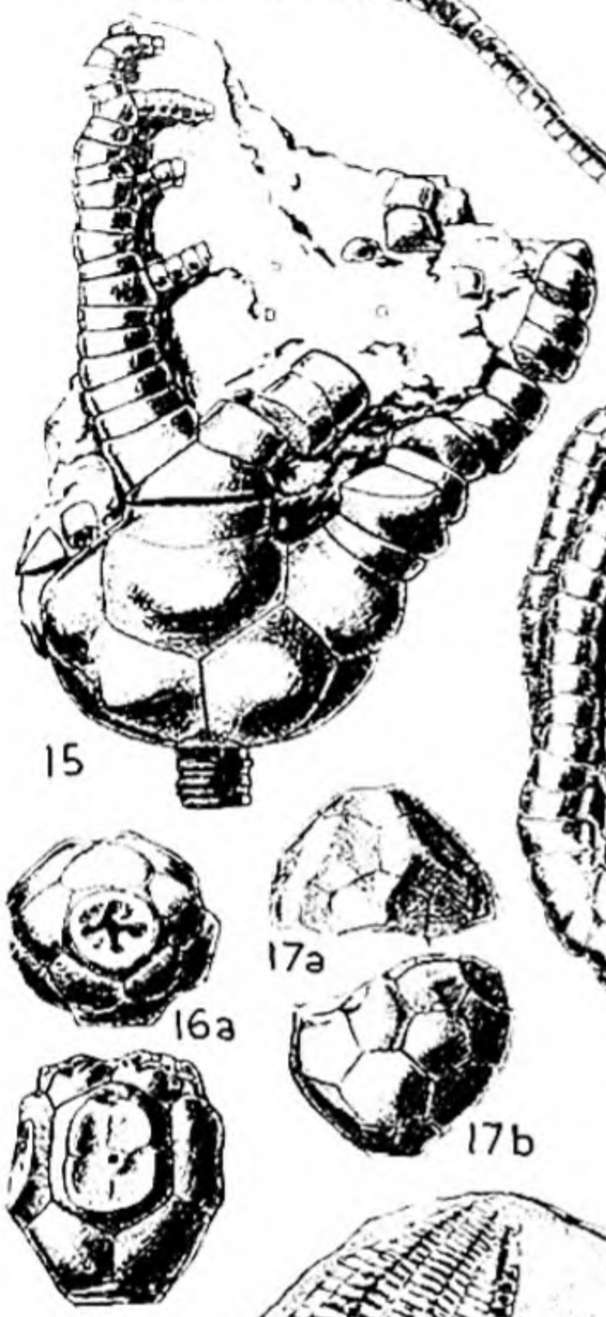
5b


6c

6a

7a

7b


8

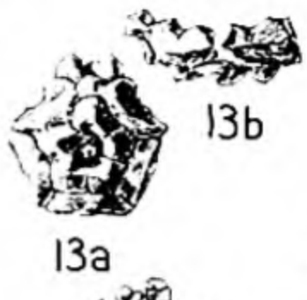
9

10

11a

11b

12


13a

13b

14a

14b

15

16a

16b

17a

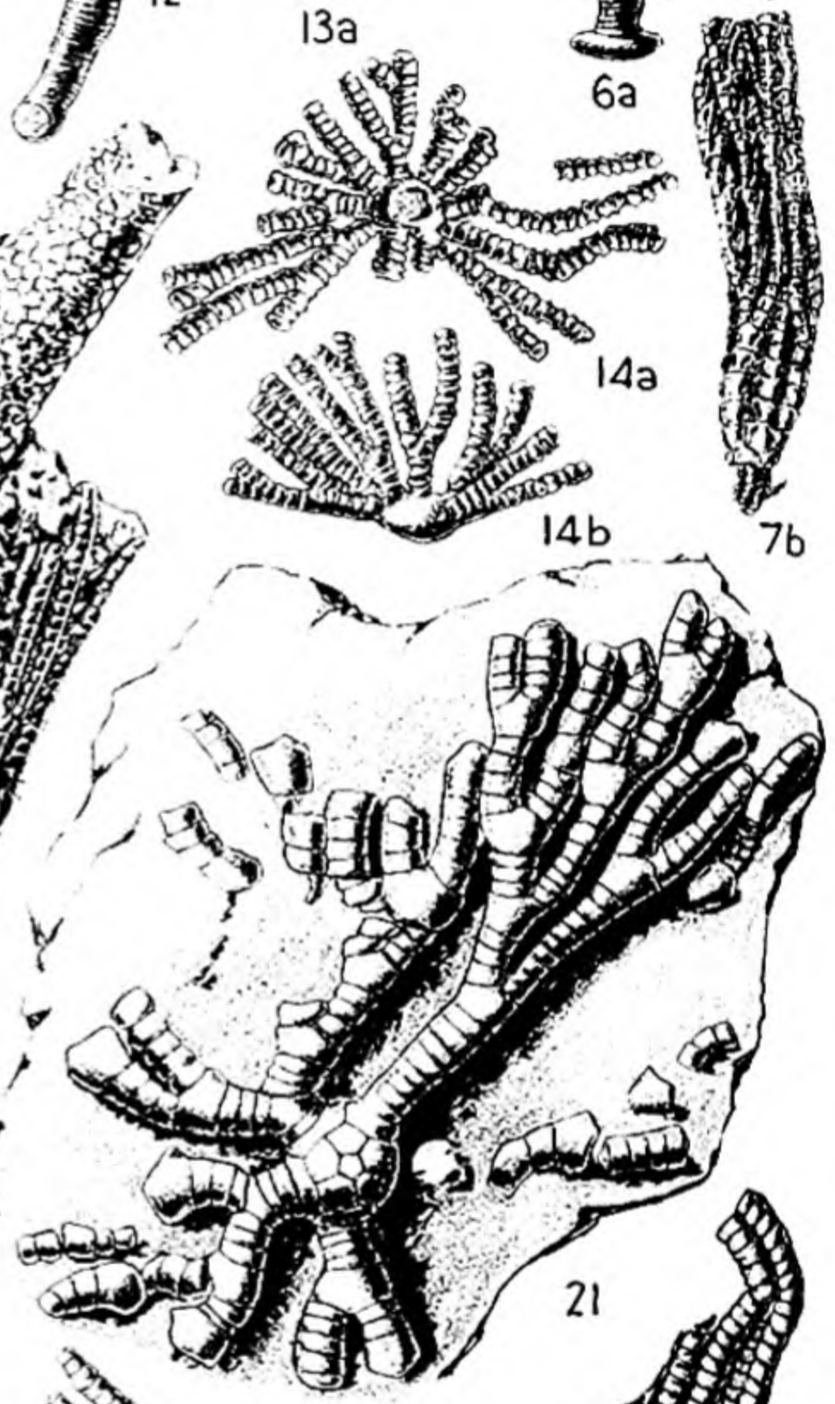
17b

18

19a

19b

20

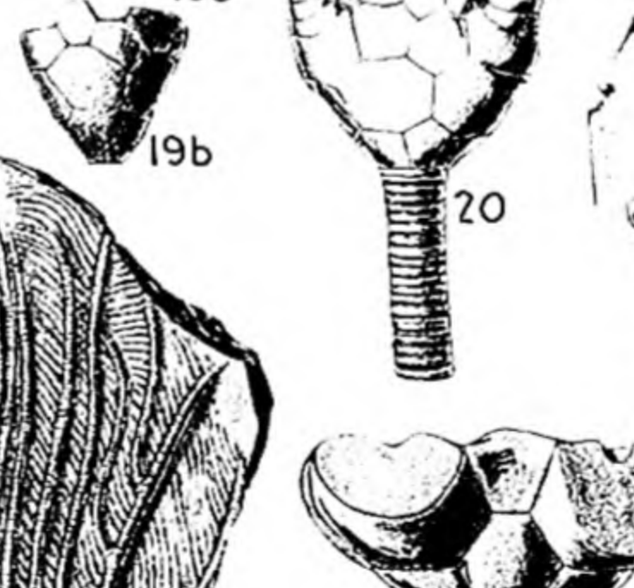

21

24

22

23a 23b

25a-c


26

27b

27a

28

29

***C. radiatus** Billings [**53**—5]. Cup slightly wider than high, subglobular (14). **Mohawkian:** Ont. (Trenton); N. Y. (Snake Hill).

C. vancortlandti Billings [**53**—6]. Cup higher than wide, ovoid, moderately large (14). **Trenton:** Ont.

Other genus: *Strophocrinus* Sardeson 1899 (120).

PALAEOCRINIDAE. Dicyclic; like Carabocrinidae except that anals in cup consist of RA and one or two additional plates, which do not adjoin the IBB. **Ord.–Dev.**

PALAEOCRINUS Billings 1859 [**52**—22]

(**P. striatus*). Like *Carabocrinus*, but has rhomboidal RA instead of iRA and sRA; anal tube small; arms slender, branching (50). **Ord.** (Chazyan, Mohawkian).

***P. striatus** Billings [**53**—19]. Prominent radiating ridges on plates of cup (50). **Trenton:** Ont.

POROCRINUS Billings 1857 [**52**—22]

(**P. conicus*). Like *Palaeocrinus* but bearing deeply grooved areas at angles of plate intersections; arms five, unbranched (14). **Ord.** (Mohawkian, Cincinnatian).

***P. conicus** Billings [**53**—13]. Cup distinctly higher than wide, conical, slightly rounded at top (14). **Trenton:** Ont.

THALAMOCRINUS Miller and Gurley 1895

(**T. ovatus*). Like *Palaeocrinus* but lacks pores normal to sutures of cup plates, which have smooth surface (142). **Sil.** (Niagaran), **Dev.** (Helderbergian).

***T. ovatus** M and G [**54**—24]. Cup ovoid, IBB prominent (142). **Niagaran:** Tenn. (Beech River).

MYSTICOCRINUS Springer 1918

(**M. wilsoni*). IBB three; RA directly below RPR, large X in line with RR; arms short, branching once (142). **Sil.** (Niagaran) (N. America only).

***M. wilsoni** Springer [**54**—23] (142). **Laurel:** Ind.

CROTALOCRINITIDAE. Dicyclic; IBB five, visible from side; PBrBr attached to narrow rounded facet and flanked by succeeding BrBr that also directly adjoin RR; RA absent, X in line with RR; stem large, round. **Sil.**

CROTALOCRINITES

T. Austin and T. Austin, Jr. 1842

(**Cyathocrinites rugosus* Miller). Arms united laterally to form flexible network (3, 142). **Sil.** (Niagaran).

C. cora (Hall) [**54**—30]. Cup relatively large, distinguished by parallel ridges crossing sutures (142, 172). **Racine:** Wis., Ill.

Other genus: *Syndetocrinus* Kirk 1933 (60).

PETALOCRINIDAE. Dicyclic; cup small, bowl-shaped; IBB minute, probably fused; RA and X absent; arms solidly fused in the form of petal-like fans. **Sil.** (Niagaran).

PETALOCRINUS Weller and Davidson 1896

(**P. mirabilis*). Arms united laterally to form five petal-like fans that bear ambulacral furrows on ventral surface; X absent (142, 170) **Sil.** (Niagaran).

***P. mirabilis** W and D [**54**—31]. Cup small; known chiefly from arm plates (142). **Hopkinton:** Ia.

GASTEROCOMIDAE. Dicyclic; cup small, bowl-shaped; IBB commonly fused but may be three or five, very low; distinct axial canal on R facets; anal vent generally through side of cup below arm bases; stem round, axial canal surrounded by three or more peripheral canals. **Dev.**

ARACHNOCRINUS Meek and Worthen 1866

(**Cyathocrinus bulbosus* Hall). Arms round, robust, branching isotomously several times (128). **Dev.**

***A. bulbosus** Hall [**57**—10, 21]. AxAx enlarged, somewhat bulbous (25). **Onondaga:** N. Y.

A. ignotus Stauffer [**57**—14]. A small species having very short BrBr that are constricted at sutures, AxAx not expanded (25). **Onondaga:** N. Y.

A. extensus Wachsmuth and Springer [**57**—29]. A robust species; arms uniformly thick, BrBr short, not strongly constricted at sutures (25). **Onondaga:** N. Y., Ky.

MYRTILLOCRINUS

G. Sandberger and F. Sandberger 1856

(**M. elongatus*). IBB fused, BB large, RR mostly covered by facet; distinguished by prominent large OO that compose almost entire tegmen; anal vent not through dorsal cup (25). **Dev.**

PLATE 57

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1a, b. Coeliocrinus lyra (84), type. Ant., post. **2a, b. Vasocrinus valens** (55), type. Post., dorsal. **3a, b. Vasocrinus sculptus** (55), type. Dorsal, post. **4. Pagecrinus gracilis** (58) (x2), type. Left post. **5, 6. Schultzicrinus typus** (25). 5a: post. showing anal opening in cup; 5b: dorsal; 6a: lat. of crown and stem; 6b: internodal columnal; 6c: nodal columnal. **7a, b. Goniocrinus sculptilis** (91), type. Ant., post. (x2). **8. Deltacrinus clarus** (25), type. Left anterolat. **9. Botryocrinus nycteus** (25). Ant. **10. Arachnocrinus bulbosus** (25). Anterolat. **11a, b. Botryocrinus americanus** (25), type. Ant., post. **12. Maragnicrinus portlandicus** (25), type. Post. **13a, b. Stellarocrinus stillativus** (178), type. Dorsal, right side. **14a, b. Arachnocrinus ignotus** (25). Dorsal views showing arms. **15. Barycrinus protuberans** (37), type. Left ant. **16a, b. Myrtillocrinus americanus** (25), type. Dorsal, lat. **17a, b. Hypselocrinus? lasallensis** (85), type. Ant., post. **18. Barycrinus wachsmuthi** (83), type. Post. **19a, b. Hypselocrinus? macoupinensis** (84), type. Ant., post. **20. Parisocrinus subramosus** (127). Post, showing sac. **21. Arachnocrinus bulbosus** (25). Dorsal. **22, 23. Botryocrinus** spp. **22. B. nycteus** (25). Post. **23a, b. B. crassus** (25), type. Right ant., post. **24. Hallocrinus ornatissimus** (25), type. Post.-lat. **25a–c. Elibatocrinus catactus** (104), type. Post. (x4), ant. (x4), post. (x2). **26. Barycrinus princeps** (91), type. Post. **27a, b. Cyathocrinites tumidus** (37), type. Post., dorsal. **28a, b. Elibatocrinus leptocalyx** (104) (x2), type. Ant., post. **29. Arachnocrinus extensus** (128), type. Part of crown showing characteristic arm branching.

M. americanus Hall [**57**—16]. Calyx ovoid; stem large, axial canal surrounded by 4 peripheral canals (25). **Onondaga:** N. Y.

SCHULTZICRINUS Springer 1911

(**S. typus*). Cup small, subglobular; IBB fused; R facets relatively wide, directed upward; anal vent just above PB; arms round, unbranched, abutting PBr_1 very short (128). **Dev.**

***S. typus** Springer [**57**—5, 6]. Column has very conspicuous nodals, axial canal surrounded by four peripheral canals (25, 128). **Onondaga:** N. Y.

Other genus: *Mictocrinus* Goldring 1923 (25).

CODIACRINIDAE. Dicyclic; cup small, sack-like; IBB three or one; RR five, or reduced partly or entirely by atrophy, facets lacking axial canal; anal vent commonly in side of cup, RA lacking; arms branched or unbranched; stem round, axial canal not accompanied by peripheral canals. **Dev.–Perm.**

DICHOSTREBLOCRINUS J. M. Weller 1930

(**D. scrobiculus*). IBB one; RR lacking; anal vent at upper right edge of PB (169). **Miss., Penn.**

***D. scrobiculus** J. M. Weller [**56**—7]. Distinguished by low OO (169). **Penn.** (Des Moines): Ind.

LECYTHIOCRINUS White 1879

(**L. olliculaeformis*). Cup ovoid; IBB three, small IB in RP ray; RR five, small, facets narrow, bearing deep ambulacral groove; anal vent at summit of PB (178). **Penn.** (Morrow–Virgil).

***L. olliculaeformis** White [**53**—21]. IBB nearly horizontal, sides of cup evenly rounded (178). **Oread:** Kan.

L. adamsi Worthen [**53**—20]. IBB slope upward distinctly; BB marked centrally by an angular bulge (191). **Des Moines:** Ill.

Other genera: *Amphipsalidocrinus* J. M. Weller 1930 (169); *Clithrocrinus* Kirk 1937 (63); *Coenocystis* Girty 1908 (166); *Lageniocrinus* Koninck and Lehon 1854 (69); *Thetidicrinus* Wanner 1916 (166, 167); *Tytthocrinus* J. M. Weller 1930 (169).

AMPHERISTOCRINIDAE. Dicyclic; cup conical to bowl-shaped; IBB three to five; RA, X and RX in cup; anal sac stout, thick-plated; arms branching several times isotomously. **Sil.–Miss.**

AMPHERISTOCRINUS Hall 1879 [**54**—29]

(**A. typus*). IBB three; sac long, slender; arms uniserial, branching isotomously at wide angles three or four times (142, 162). **Sil.** (Niagaran).

***A. typus** Hall [**54**—28] (142). **Niagaran:** Ind. (Waldron), Tenn. (Beech River).

PARISOCRINUS Wachsmuth and Springer 1879

(**Poteriocrinus perplexus* Meek and Worthen). RA large; anal sac tall, plate borders perforated; arms branch isotomously twice or more (162). **Sil.–Miss.**

P. siluricus Springer [**55**—13]. Cup small, evenly conical, anal sac tilted posteriorly; PBrBr two (142). **Sil.:** Ind. (Laurel).

P. subramosus (Miller and Gurley) [**57**—20]. Cup rather large, bowl-shaped; anal sac very large, plate perforations prominent; PBrBr three or four (127). **Miss.:** Ind. (Keokuk).

VASOCRINUS Lyon 1857 [**52**—23]

(**V. valens*). Like *Botryocrinus* but having RX, as well as X and pentagonal RA in cup; arm facets horseshoe-shaped, directed almost straight outward; stem round (55). **Dev.**

***V. valens** Lyon [**57**—2]. Plates smooth (55). **Onondaga:** Ky

V. sculptus Lyon [**57**—3]. Plates marked by very prominent radiating ridges (55). **Dev.:** Ohio (Hamilton), Ind., Ky. (Sellersburg).

Other genus: *?Closterocrinus* Hall 1852 (36).

LECYTHOCRINIDAE. Genera: *Corynecrinus* Kirk 1934 (61), *Cestocrinus* Kirk 1940 (70).

BARYCRINIDAE. Dicyclic; cup low conical or bowl-shaped, mostly thick-plated; IBB five; X and quadrangular RA in cup; moderately strong anal sac; arms round, stout, branching isotomously once, or rarely more than once, in each ray and bearing branchlets at intervals; stem large, round. **Miss.**

BARYCRINUS Wachsmuth 1868

(**Cyathocrinus spurius* Hall). Cup broad bowl-shaped, plates thick; RA small, quadrangular; anal tube broad and short; arms round, massive, 10 main branches, giving off branchlets heterotomously; stem large, divided into fifths, axial canal wide (162). **Miss.**

B. protuberans (Hall) [**57**—15]. Distinguished by strongly bulging cup plates, surface finely granulose (37). **Keokuk:** Ill.

B. wachsmuthi (Meek and Worthen) [**57**—18]. Like *B. protuberans* but plates less convex, finely ridged ornamentation, and some arms branch on SBr_4 as well as PBr_2 (83). **Burlington:** Ia.

B. princeps Miller and Gurley [**57**—26]. Plates smooth, depressed at angles; one of main arms of LP and RP rays branches isotomously, PBrBr six in LA and RA rays, two in others (91). **Keokuk:** Ind.

Other genus: *Pellecrinus* Kirk 1929 (55).

CYATHOCRINITIDAE. Dicyclic; like Barycrinidae but having no RA; arms branch isotomously several times, nonpinnulate; stem typically round. **Sil.–Perm.**

CYATHOCRINITES Miller 1821 [**52**—12]

(*C. planus*). IBB five, visible from side; R facets horseshoe-shaped, directed outward; X in line with RR, resting on PB; arms branch several times isotomously; stem large, round (3). **Sil.–Perm.**

C. wilsoni Springer [**54**—21]. Distinguished by the conical form of its cup and round elongate BrBr (142). **Sil.:** Ind. (Laurel).

C. tumidus Hall [57—27]. Cup low and wide, plates gently convex, R facets large (37). **Miss.:** Ill. (Keokuk).

GISSOCRINUS Angelin 1878

(**G. arthriticus*). Like *Cyathocrinites* but having only three IBB (142). **Sil., Dev.**

G. lyoni Springer [55—12]. Cup low, arms stout, angular (142). **Sil.:** Ky. (Louisville).

Suborder Dendrocrinoidea. Cladoidea having primitively a steeply conical cup but in later forms a bowl-shaped, globose, or discoid cup that may be concave at the base; tegmen strongly inflated in form of an anal sac; radial facets rounded or occupying entire distal edge of radials; arms branching isotomously and heterotomously, tending to development of pinnules. **Ord.–Trias.**

MEROCRINIDAE. Dicyclic; cup conical; R facets wide; iRA in position of RPR, supporting sRA, which has form of PBrAx and is outside of cup; X on left shoulder of sRA, followed by an anal tube that resembles an arm; arms branch isotomously more than once; stem round. **Ord.**

MEROCRINUS Walcott 1883

(**M. typus*). Only genus assigned to family. Like *Iocrinus* but dicyclic (5, 164). **Ord.** (Mohawkian, Cincinnatian).

***M. typus** Walcott [53—16]. Relatively large, cup low, arms thick (164). **Trenton:** N. Y.

M. corroboratus Walcott [53—17]. Distinguished from *M. typus* by smaller size and more slender arms (164). **Trenton:** N. Y.

CUPULOCRINIDAE. Dicyclic; cup subconical; IBB five, visible from side; RA directly below RPR, X in line with RR; anal sac well developed, a vertical series of large plates resting on X; arms branching isotomously twice or more, formed of wide short BrBr. **Ord.**

CUPULOCRINUS Orbigny 1849 [52—16]

(**Scyphocrinus heterocostalis* Hall). Only genus assigned to family; facets of BrBr strikingly resemble those of a flexible crinoid but the anal sac and the presence of five IBB, instead of three, differentiate it from the Flexibilia (127). **Ord.** (Mohawkian–Richmond).

C. jewetti (Billings) [53—12]. Plates show distinct convexity, sutures impressed, those of BrBr tending to be flexuous; alternate columnals slightly enlarged (127). **Trenton:** Ont.

***C. heterocostalis** Hall [53—9]. Cup small, plates smooth, arms branching regularly, Br sutures straight (127). **Trenton:** N. Y.

C. humilis (Billings) [53—7, 25]. Cup relatively large, sutures of cup and arms not impressed, straight; prominent nodal columnals at intervals along stem (127). **Trenton:** Ont.

DENDROCRINIDAE. Dicyclic; cup conical or bowl-shaped; IBB visible from side; RA directly or obliquely below RPR, X in line with RR, followed by sac plates; anal sac well developed, plates plicate; arms slender, branching isotomously several times. **Ord.–Miss.**

DENDROCRINUS Hall 1852 [52—6]

(**D. longidactylus*). IBB five; RA directly below RPR, large X in line with RR, followed by sac formed of subequal hexagonal plates in longitudinal rows; PBrBr three, branches isotomous, slender, nonpinnulate; stem round (3). **Ord., Sil.**

***D. longidactylus** Hall [52—6]. Cup conical; arms long, very slender, branching several times (36). **Sil.:** N. Y. (Clinton).

BOTRYOCRINIDAE. Dicyclic; cup conical or bowl-shaped; IBB visible from side; RA obliquely below RPR, X in line with RR; tegmen lacks clearly differentiated OO and commonly is extended into a sac; main arms branch isotomously and these divide heterotomously, giving off branchlets that may subdivide or remain undivided, like pinnules. **Sil.–Miss.**

BOTRYOCRINUS Angelin 1878 [52—9]

(**B. ramosissimus*). Cup bowl-shaped; IBB visible from side; axial canal on R facets; RA small, quadrangular; anal sac large; arms round, dividing isotomously once in each ray, then giving off branchlets or pinnules heterotomously (3). **Sil., Dev.**

B. polyxo (Hall) [54—22]. Distinguished by angulated form of plates; axial canal of stem very large (44). **Sil.:** Ind. (Waldron).

B. nycteus (Hall) [57—9, 22]. Distinguished by evenly conical form of cup; plates granulose; PBrBr three in each ray (25). **U. Dev.:** N. Y. (Hamilton).

B. crassus (Whiteaves) [57—23]. Greatest width of cup less than its height, form bell-shaped (25). **Dev.:** Ont. (Hamilton).

B. americanus Rowley [57—11]. Cup low, subquadrangular outline in side view (25). **Dev.:** Ind. (Hamilton).

Other genera: *Atelestocrinus* Wachsmuth and Springer 1886 (162), *?Streptocrinus* Wachsmuth and Springer 1886 (162).

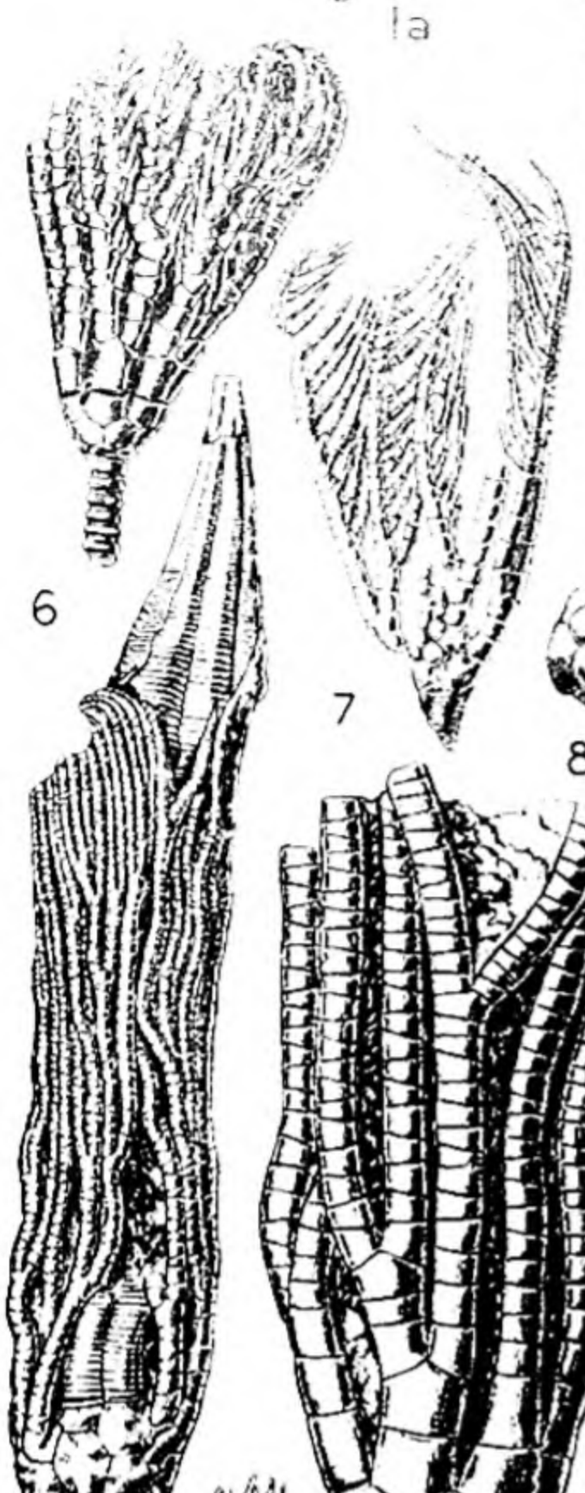
POTERIOCRINITIDAE. Dicyclic; cup steeply conical; IBB five, visible from side; R facets horseshoe-shaped, sloping definitely outward and distinctly less than greatest width of RR, bearing poorly defined articular transverse ridge; RA, X, RX in cup; arms long, rather slender, uniserial, branching isotomously at irregular intervals, pinnulate, PBrBr several in each ray. **Dev.–Perm.**

POTERIOCRINITES Miller 1821 [52—18]

(**P. crassus*). Facets about half width of RR; anal sac tall, slender, fragile; stem round (128). **Dev.–Perm.**

P. macropleurus (Hall) [58—3]. Cup moderately

1a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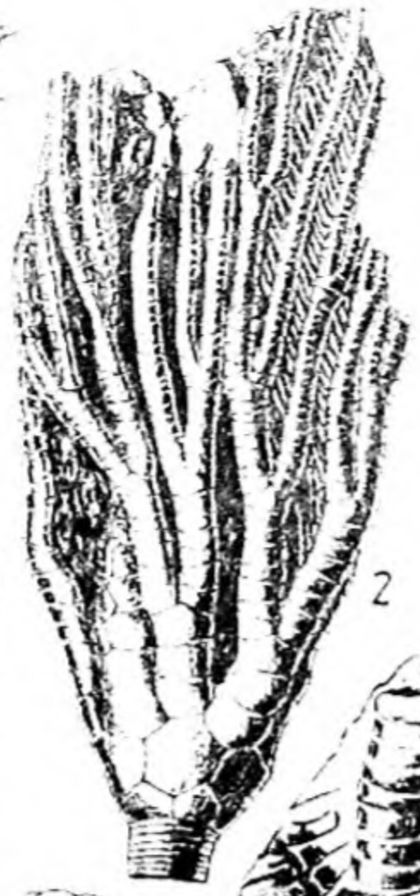

2

7

8a 8b 8c

3a

3b

9

4a

4b

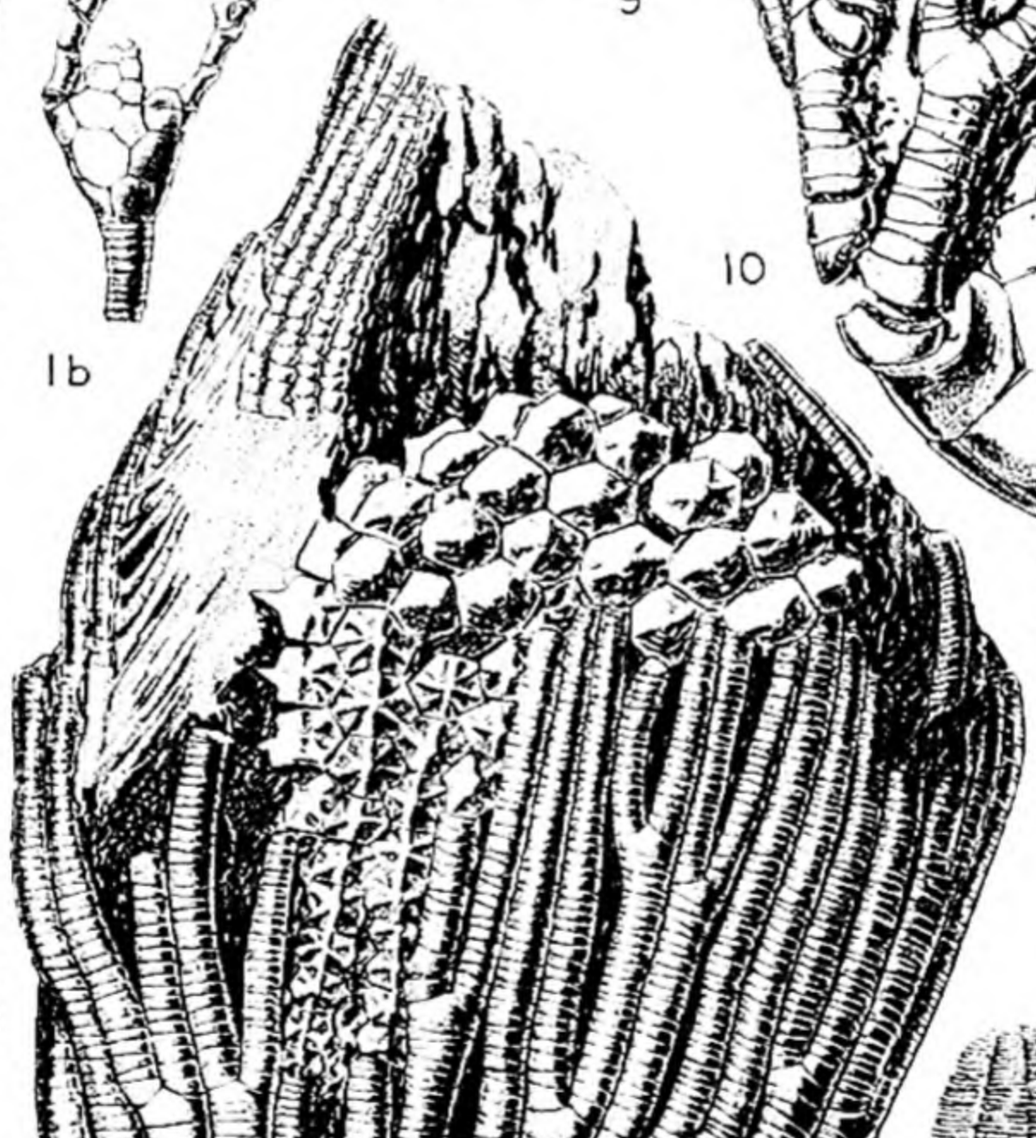
5a 5c

11a

5b 11b

1b

10



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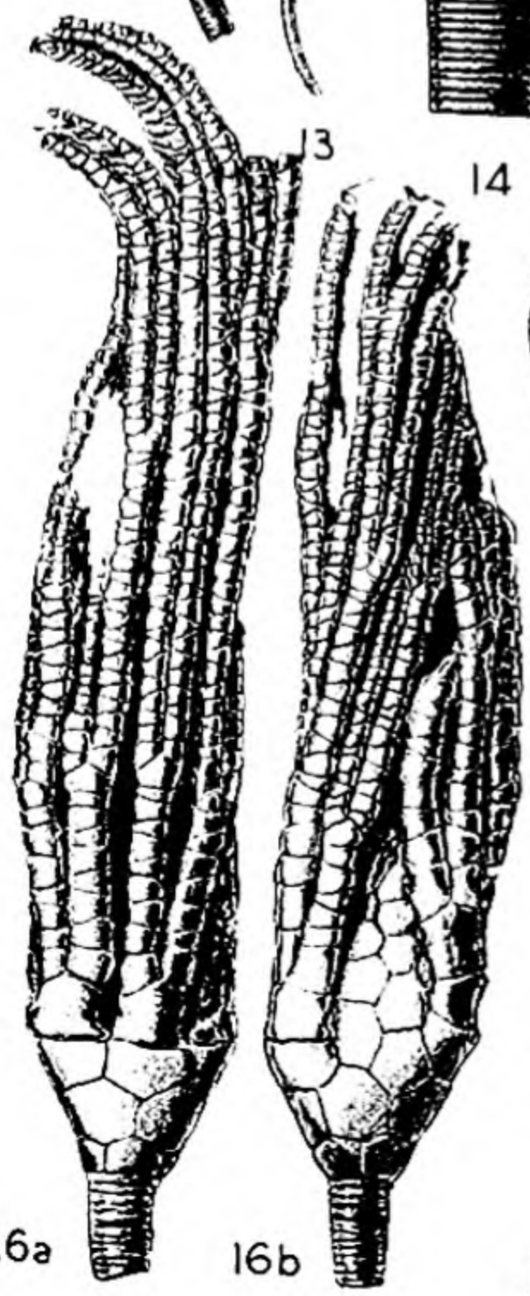

13

14

15

16a

16b

17

18

19

20

21a 21b

large, sides broadly flaring, plates strongly folded at margins (128). **Miss.:** Ia. (Burlington), N. Mex. (Lake Valley).

SPRINGERICRINUS Jaekel 1918

(**Poteriocrinus magniventrus* Springer). Like *Poteriocrinites* but distinguished by its very large, thin-plated anal sac bearing close-spaced horizontal ridges (51). **Miss.** (Osage).

S. doris (Hall) [58—12]. Crown tall, slender; cup small (128). **Burlington:** Ia.

***S. magniventrus** (Springer) [58—9, 19]. Largest known species; sac plates bear a median rib running vertically, the structure of row of these plates resembling an arm with laterally directed pinnules (128). **Keokuk:** Ind.

GLOSSOCRINIDAE. Dicyclic; cup conical to deep bowl-shaped; IBB five, visible from side; arm facets equal or nearly equal to width of RR; one to three XX in cup, followed by tall anal sac, mostly formed of thin plates having folded borders; main arms branch isotomously, giving off slender unbranched ramules or pinnules. **Dev., Miss.**

MARAGNICRINUS Whitfield 1905

(**M. portlandicus*). Arms branch only once in each ray, on PBr_3, pinnules very long and slender (25). **U. Dev.**

***M. portlandicus** Whitfield [57—12]. Plates ornamented by fine irregular ridges; only described species (25). **Portage:** N. Y.

HALLOCRINUS Goldring 1923

(**Cyathocrinus ornatissimus* Hall). Like *Maragnicrinus* except that arms branch endotomously at regular intervals, pinnules abundant; anal sac large, formed of vertical rows of thin plicated plates (25). **U. Dev.**

***H. ornatissimus** (Hall) [57—24]. Only described species (25). **Portage:** N. Y.

CYDROCRINUS Kirk 1940

(**Poteriocrinus coxanus* Worthen). Crown elongate, subcylindrical; cup steeply conical; facets slightly less than maximum width of RR; arms robust, branches numerous, PBrBr two in each ray; anal sac less than arm height, but prominent (71). **Miss.** (Osage).

C. subramulosus (Worthen) [58—2]. A small species; sac plates not ridged (191). **Keokuk:** Ia.

***C. coxanus** (Worthen) [58—18]. A robust species; sac plates bear stellate ridges (191). **Keokuk:** Ill.

Other genera: *Catactocrinus* Goldring 1923 (25), *Charientocrinus* Goldring 1923 (25), *Glossocrinus* Goldring 1923 (25), *Liparocrinus* Goldring 1923 (25).

PELECOCRINIDAE. Dicyclic; cup bowl-shaped, base convex or slightly concave; R facets sloping rather steeply outward, distinctly narrower than RR; three XX in cup; arms rounded, branching isotomously, not appressed, PBrBr one or two in each ray except A, BrBr cuneate, uniserial to biserial. **Miss.–Perm.**

PELECOCRINUS Kirk 1941

(**P. insignis*). Cup large; IBB visible from side; RA in normal position obliquely below RPR; PBrBr 10 or more above AR, arms uniserial; stem round (72). **Miss.** (Osage).

P. aqualis (Hall) [55—19]. Relatively small species; anal sac reaching nearly to height of arms, bearing terminal spine (140). **Burlington:** Ia.

***P. insignis** Kirk [58—10]. Robust species having ovoid crown; cup broad, shallow (72). **Burlington, Keokuk:** Ia.

STELLAROCRINUS Strimple 1940

(**Cyathocrinus stillativus* White) [52—14]. Cup shallow, having flat or concave base; IBB not visible from side; lowest anal rests on truncated tip of PB; one PBr in each ray, possibly excepting A, SBrBr may be in contact with RR, arms uniserial to biserial; sac bears terminal spine. **Penn.** (Des Moines–Virgil).

S. florealis (Moore and Plummer) [60—14]. Smaller, slightly higher cup than *S. geometricus*, ridges reduced to elongate nodes (108). **Millsap Lake:** Tex.

S. geometricus (Moore and Plummer) [58—5]. Distinguished by prominent ridges crossing sutures between RR and BB (108). **Iola:** Kan.

***S. stillativus** (White) [57—13]. Crest on BB forms slightly overhanging wall surrounding IBB; fine granulose ornamentation (149, 178). **Oread:** Kan.

Other genus: *Malaiocrinus* Wanner 1924 (108, 166).

APOGRAPHIOCRINIDAE. Dicyclic; cup small,

PLATE 58

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after specific name.]

1a, b. Logocrinus geniculatus (25), type. Ant.-lat., post. (x2). **2. Cydrocrinus subramulosus** (191), type. Right post. **3a, b. Poteriocrinites macropleurus** (128). Ant. of cup; detached radial. **4a, b. Biothrocrinus spartarius** (78, 91). Left ant., post. **5a–c. Stellarocrinus geometricus** (108), type. Post., ventral, dorsal. **6. Cosmetocrinus elegantulus** (91) (x2), type. Ant. **7. Corematocrinus plumosus** (25), type. Post. of cup, base of arms, lower plates of sac bearing transverse ribs. **8a–c. Apographiocrinus exculptus** (108), type. Dorsal, ventral, post. **9. Springericrinus magniventrus** (128), type. Post. **10. Pelecocrinus insignis** (72), type. Post. **11a, b. Biothrocrinus swallovi** (82), type. Post., ant. **12. Springericrinus doris** (128). Post. **13. Logocrinus infundibuliformis** (25). Ant. **14–16. Cosmetocrinus spp. 14. C. crawfordsvillensis** (91), type. Ant. **15. C. nanus** (84), type. Ant. **16a, b. C. gracilis** (72), type. Ant., post. **17. Hypselocrinus arcanus** (91), type. Ant. **18. Cydrocrinus coxanus** (191), type. Ant. view showing upper part of sac. **19. Springericrinus magniventrus** (128). Distal end of sac. **20. Biothrocrinus jesupi** (183) (x0.5), type. Post. **21a, b. Cosmetocrinus elegantulus.** Ant. (91); type of Wachsmuth and Springer (78).

truncate bowl-shaped, base shallowly concave; IBB not visible from side; R facets less than width of plates, divided by prong-like projections of outer surface of RR, surface of facets sloping inward, transverse ridge well developed; X in line with RR; arms 10, uniserial, one PBr in each ray; stem round. **Penn., Perm.**

APOGRAPHIOCRINUS
Moore and Plummer 1940 [**62**—28]

(**A. typicalis*). IBB five, in shallow concavity; arms appressed, their outer face somewhat flattened (108). **Penn., Perm.**

***A. typicalis** M and P [**56**—21; **62**—22]. Surface smooth, upper margin of RR rounded (108). **Penn.** (Missouri): Kan., Okla. (Plattsburg, Stanton), Tex. (Palo Pinto).

A. exculptus Moore and Plummer [**58**—8]. Granules on base of cup and on angulated areas of RR below facets (108). **Penn.:** Tex. (Mineral Wells).

OTTAWACRINIDAE [**52**—5]. Dicyclic; cup conical; IBB five, visible from side; arm facets occupying entire summit of RR but generally narrower than greatest width of RR; RA directly or obliquely below RPR, X in line with RR; anal sac large; main arms divide isotomously and give off slender unbranched ramules. **Ord.–Miss.**

OTTAWACRINUS W. R. Billings 1887 [**52**—5]

(**O. typus*). RA large, in line with RR, except RPR, which is directly above it in position of PBr, X on distal tip of PB, followed by sac plates; arms branch isotomously on PBr_3 or higher and show heterotomous branching above (5, 127). **Ord.** (Mohawkian).

O. billingsi Springer [**53**—23]. Large species; sac plates marked by stellate ridges; a few IBrBr present (127). **Trenton:** Ont.

***O. typus** W. R. Billings [**53**—24]. Arms long, branching repeatedly; sac plates small, not ridged (127). **Trenton:** Ont., Que.

LASIOCRINUS Kirk 1914 [**52**—5]

(**Homocrinus scoparius* Hall). RA quadrangular, obliquely below RPR; anal sac tall, slender; PBrBr three to six, upper arms divide heterotomously on each fourth or fifth Br, giving off a slender unbranched ramule; stem round or obtusely pentagonal (25, 54, 122). **Dev., Miss.**

***L. scoparius** (Hall) [**52**—5, **53**—15]. Relatively large, cup steeply conical, arms stout (54). **Dev.:** N. Y. (Coeymans).

L. expressus Laudon [**53**—14]. Differs from *L. scoparius* in lower cup and fewer, more slender arms (74). **Miss.:** Ia. (Hampton).

CRADEOCRINUS Goldring 1923

(**C. elongatus*). Calyx slender, elongate; R facets wide; arms branch isotomously on PBr_3 or PBr_4, and above this branch heterotomously, giving off slender ramules on alternate sides (25). **Dev.**

***C. elongatus** Goldring [**53**—18]. Distinguished by elongate cup and size (25). **Chemung:** N. Y.

GONIOCRINUS Miller and Gurley 1890

(**G. sculptilis*). RA obliquely below RPR, X in line with RR, followed by vertical series of sac plates; arms branching isotomously on PBr_3 or PBr_4 and heterotomously at higher points; stem pentagonal (91). **Miss.** (Kinderhook).

***G. sculptilis** M and G [**57**—7]. RA very small, quadrangular; plates of cup sculptured, BrBr flanged (78). **Hampton:** Ia.

?PAGECRINUS Kirk 1929

(**P. gracilis*). BB largest plates of cup; RA absent, X in line with RR; arms branch isotomously on PBr_3 or PBr_4 and above this give off ramules heterotomously on alternate sides; anal tube slender, tall (58). **Dev.**

***P. gracilis** Kirk [**57**—4]. Only described species (58). **Jeffersonville:** Ind.

Other genera: *Iteacrinus* Goldring 1923 (25), *?Alsopocrinus* Tansey 1922.

BLOTHROCRINIDAE [**52**—21]. Dicyclic; cup conical; IBB five (or ?three), visible from side; arm facets wide, bearing a well developed transverse ridge; anal sac very tall, slender; arms round, uniserial, anterior arm may be unbranched, two or more isotomous divisions in other rays. **Miss.–Perm.**

BLOTHROCRINUS Kirk 1940

(**Poteriocrinus jesupi* Whitfield). Cup steeply conical; XX in cup, three; arms branch on PBr_2 and at irregular intervals above, BrBr cuneate; stem round (71). **Miss.** (Kinderhook, Osage).

***B. jesupi** (Whitfield) [**58**—20]. A very robust species; crown pyriform; arms long (183). **Burlington:** Ia.

B. spartarius (Miller and Gurley) [**58**—4]. A medium-sized species; arms somewhat slender; crown broadly expanded at top (78, 91). **Hampton:** Ia.

B. swallovi (Meek and Worthen) [**58**—11]. BrBr wide and short (82). **Burlington:** Ia.

ULRICHICRINUS Springer 1926

(**U. oklahomae*). Crown moderately tall, slender; XX in cup, three; rami three or four to each ray, PBr_1 and SBr_1 axillary; stem round (140). **Miss., Penn.**

U. coryphaeus (S. A. Miller) [**59**—13]. A small species; BrBr relatively elongate (140). **Miss.:** Ind. (Keokuk).

***U. oklahomae** Springer [**59**—14]. BrBr cuneate, very short (140). **Penn.:** Okla. (Morrow).

STINOCRINUS Kirk 1941

(**S. granulosus*). Crown subcylindrical, moderately tall; XX in cup, three; arms branch isotomously on PBr_2 (except in anterior ray, to PBr_9) and on SBr_8 or nearby, rami laterally in contact, BrBr quadrate (72). **Miss.**

S. manus (Miller and Gurley) [**60**—15] (91). **Keokuk:** Ind.

CULMICRINUS Jaekel 1918 [**52**—21]

(**Poteriocrinus regularis* Meyer). XX in cup, three; arms slender, few, anterior ray typically undivided, BrBr cuneate, PBrBr six or more on all rays (140). **Miss.** (Kinderhook–Chester).

C. elegans (Wachsmuth and Springer) [**59**—9]. A large species distinguished mainly by features of arms and sac (140). **Chester:** Ky.

C. missouriensis (Shumard) [**59**—6]. Differs from *C. elegans* in the higher first division of arms (140). **St. Louis:** Mo.

COSMETOCRINUS Kirk 1941

(**C. gracilis*). Crown tall, slender; XX in cup, three; BrBr quadrangular to cuneate, arms branch isotomously on PBr_1 in all rays and once or twice at higher positions; sutures between RR and PBrBr gaping (72). **Miss.** (Kinderhook, Osage).

C. elegantulus (Wachsmuth and Springer) [**58**—6, 21]. Crown small, pyriform; cup relatively low and PBrBr elongate (72, 78). **Hampton:** Ia.

C. nanus (Meek and Worthen) [**58**—15]. A small species, distinguished by form of cup and prominent PBrBr (84). **L. Burlington:** Ia.

***C. gracilis** Kirk [**58**—16]. Arms slender, BrBr distinctly cuneate, SBrBr 8 to 10 (72). **Borden:** Ind.

C. crawfordsvillensis (Miller and Gurley) [**58**—14]. Cup more steep sided and arms stouter than in *C. gracilis*; RR tend to stand separate; BrBr not strongly cuneate (91). **Borden:** Ind.

ELIBATOCRINUS Moore 1940

(**E. leptocalyx*). Cup very steep sided; three IBB; R facets wide but short; three XX in cup; arms branch isotomously on PBr_1, BrBr cuneate, elongate, keeled, pinnules large; stem round (104). **Penn.** (Missouri, Virgil).

***E. leptocalyx** Moore [**57**—28, **62**—23]. Plates smooth (104). **Stanton:** Kan.

E. catactus Moore [**57**—25]. A small species; plates granulose (104). **Oread:** Kan.

NEBRASKACRINUS Moore 1939

(**N. tourteloti*). Cup steeply conical; XX in cup, three; anal sac prominent; arms branch heterotomously on PBr_1 and SBr_2, rami three or more to ray; stem round (103). **L. Perm.**

***N. tourteloti** Moore [**60**—13] (103). **L. Perm.:** Neb. (Winfield), Kan.

Other genera: *Bursacrinus* Meek and Worthen 1861 (162), *Haeretocrinus* Moore and Plummer 1940 (108), *Carcinocrinus* Laudon 1941 (77), *?Hydriocrinus* Trautschold 1867 (107), *Lebetocrinus* Kirk 1940 (68), *?Melbacrinus* Strimple 1940 (148).

CERCIDOCRINIDAE [**52**—20]. Dicyclic; crown pyriform; cup conical; IBB five, plainly visible from side; facets equal width of RR; three XX in cup, anal sac prominent; arms uniserial, branching endotomously. **Miss.**

CERCIDOCRINUS Kirk 1938 [**52**—20]

(**Poteriocrinus bursaeformis* White). Cup steeply conical; anal sac subcylindrical (65). **Miss.** (Kinderhook, Osage).

C. infrequens (Laudon and Beane) [**60**—20] A small form; rami slender (78). **Hampton:** Ia.

***C. bursaeformis** (White) [**59**—10]. A robust species; arms branch several times, BrBr short quadrate (140). **L. Burlington:** Ia.

COELIOCRINUS White 1863

(**Poteriocrinus dilatatus* Hall). Cup low, conical or bowl-shaped; distinguished by balloon-shaped expansion of distal part of anal sac (140). **Miss.** (Osage).

***C. dilatatus** (Hall) [**55**—18]. A small species having few arm divisions (140). **Burlington:** Ia.

C. lyra (Meek and Worthen) [**57**—1]. Arms thick, branching several times endotomously (140). **Burlington:** Ia.

C. subspinosus White [**59**—1]. Distinguished by spines on anal sac (140). **Burlington:** Ia.

C. ventricosus (Hall) [**55**—20]. Distal part of sac subglobular, its plates marked by prominent ridges having starlike pattern (140). **Burlington:** Ia.

ASCETOCRINUS Kirk 1940

(**Scaphiocrinus rusticellus* White). Cup steeply conical; arms branch isotomously on PBr_1 and endotomously at higher points, six or more rami to each ray; stem pentagonal to round (71). **Miss.** (Osage–Chester).

***A. rusticellus** (White) [**55**—14] (140). **Burlington:** Ia.

A. scoparius (Hall) [**55**—17]. Anal sac recurved (140). **Chester:** Ky.

PACHYLOCRINIDAE. Dicyclic; crown tall, slender; cup truncate cone- or bowl-shaped, base somewhat concave; IBB not visible from side; R facets wide, bearing distinct transverse ridge, muscle- and ligament-areas; three XX in cup; arms branching isotomously twice or more, regularly or irregularly. **Miss.–Perm.**

ABROTOCRINUS Miller and Gurley 1890

(**A. cymosus*). Arms round, slender, composed of short quadrate BrBr, PBrBr axillary except in anterior ray, two to four isotomous divisions of rami, axillaries relatively large, projecting; stem subpentagonal proximally to round distally (91) **Miss.** (Osage).

***A. cymosus** M and G [**60**—1]. Crown slender; rami very long, four or more divisions along a single arm and ramus (91). **Keokuk:** Ind.

A. unicus (Hall) [**59**—15]. Differs slightly from *A. cymosus* in shape of cup, crown shorter, branching of rami fewer (140). **Keokuk:** Ind.

1a

2c

2a

2d

3a

3b

3c

1b

4b

4d

2b

4c

5a

5b

6

7

4a

8a

8b

9

10

11a

11b

12

13

14

15a

15b

HYLODECRINUS Kirk 1941

(**H. sculptus*). Like *Abrotocrinus* but arms branch endotomously, dividing first on PBr_2 in all rays and generally having two divisions of rami (72). **Miss.** (Osage).

***H. sculptus** Kirk [**60**—12]. Angles between plates of cup deeply excavated (72). **Keokuk:** Ind.

H. asper Kirk [**60**—4]. Differs from *H. sculptus* in appearance of cup and in its shorter, stouter arms (72). **Keokuk:** Ind.

DASCIOCRINUS Kirk 1939

(**Cyathocrinus florealis* Yandell and Shumard). Like *Abrotocrinus* except that anterior arm divides on PBr_1 and branching of rami is endotomous, SBrBr numerous in all rami; anal sac as tall as arms; stem round (66). **Miss.** (Chester).

***D. florealis** (Y and S) [**61**—4] (66). **Glen Dean:** Ky.

PACHYLOCRINUS Wachsmuth and Springer 1880

(**Scaphiocrinus aequalis* Hall). Crown lower and broader than that of *Abrotocrinus*; arms divide isotomously on PBr_2 in all rays and two or three times above; stem round (140). **Miss.**

P. globosus (Wachsmuth and Springer) [**60**—17]. A small crinoid having few branches (78). **Hampton:** Ia.

***P. aequalis** (Hall) [**61**—10]. A moderately large species; plates ornamented by granules (140). **Keokuk:** Ind.

P. lacunosus (Miller and Gurley) [**64**—21]. BrBr rugose, branching of arms shows tendency toward endotomy (91). **Keokuk:** Ia.

DINOTOCRINUS Kirk 1941

(**D. compactus*). Differs from *Abrotocrinus* in its shorter, broader crown; division of arms uniformly on PBr_1 followed typically by one isotomous branching of each ramus; stem round (73). **Miss.** (Meramec, Chester).

***D. compactus** Kirk [**61**—12] (73). **Ste. Genevieve:** Ala.

PLUMMERICRINUS Moore and Laudon 1943

(**Pachylocrinus mcguirei* Moore). Like *Pachylocrinus* but each PBr_1 is axillary (103). **Penn., Perm.**

***P. mcguirei** (Moore) [**63**—20]. RR spread outward so that arm facets are separated, sutures between plates of cup depressed; few divisions of arms; anal sac recurved (103). **Penn.:** Okla. (Brownville).

P. ogarai (Moore and Plummer) [**62**—35, **63**—19]. Distinguished by shape of cup and appearance of plates (108). **Penn.:** Tex. (Graford).

P. uddeni (Moore and Plummer) [**63**—18]. Cup large, plate sutures not strongly depressed; differs from *P. ogarai* in shape of cup (108). **Penn.:** Tex. (Mineral Wells).

Other genera: *Texacrinus* Moore and Plummer 1940 (108), *Rhopocrinus* Kirk 1942.

PIRASOCRINIDAE. Dicyclic; crown compact; cup low, base flat or concave; IBB five, not visible from side; R facets wide and moderately long, sloping gently outward, having distinct transverse ridge, muscle- and ligament-areas; three XX in cup; sac prominent, mushroom-shaped; arms uniserial, branching twice or more isotomously. **Miss.–Perm.**

ADINOCRINUS Kirk 1938

(**Zeacrinus nodosus* Wachsmuth and Springer). Cup has broad shallow basal concavity; BB very small, separated laterally by RR, which touch IBB; PBr_1 axillary in all rays except anterior, which has about five PBrBr (65). **Miss., Penn.**

***A. nodosus** (W and S) [**60**—25, **62**—4]. BrBr somewhat cuneate and strongly nodose (162). **Miss.:** Tenn. (Keokuk).

A. compactilis (Worthen) [**60**—23]. BrBr quadrate, not nodose, but AxAx are protuberant (84). **Miss.:** Ky. (Osage).

A. pentagonus (Miller and Gurley) [**60**—24]. An arcuate ridge crosses each R transversely; arms unknown (91). **Penn.:** Mo. (Missouri).

PERIMESTOCRINUS Moore and Plummer 1938

(**Hydreionocrinus noduliferus* Miller and Gurley). Cup low bowl-shaped; proximal parts of BB form walls of a rather constricted, steep-sided basal concavity (107, 108). **Penn., Perm.**

P. teneris Moore and Plummer [**64**—11]. A very small species; sides of cup evenly flaring, sutures impressed (107). **Penn.:** Ark. (Brentwood).

P. pumilis Moore and Plummer [**64**—4]. Like *P. teneris* but larger and sides of cup steeper (107). **Penn.:** Okla. (Morrow).

P. calyculus Moore and Plummer [**64**—2]. Cup low, sutures slightly impressed (108). **Penn.:** Tex. (Mineral Wells).

P. impressus Moore and Plummer [**62**—8, **64**—12]. Basal concavity very sharply defined, sutures strongly impressed; fine granulose ornamentation (108). **Penn.** (Des Moines, Missouri): Mo., Kan., Okla., Tex.

P. formosus Moore and Plummer [**64**—3]. Dis-

PLATE 59

(Figures are x1 unless otherwise indicated; all figures after Springer (140).)

1a, b. Coelocrinus subspinosus. Post., ant. **2a–d. Tholocrinus spinosus.** Post., ant., ventral, dorsal. **3a–c. Linocrinus wachsmuthi.** Left post., ant. post, right post., right ant. **4a–d. Tholocrinus wetherbyi.** Right post., dorsal, ventral, post. **5a, b. Linocrinus arboreus.** Left post., ant. **6. Culmicrinus missouriensis.** Ant. **7, 8. Decadocrinus** spp. **7. D. tumidulus.** Post. **8a, b. D. halli.** Post., ant. **9. Culmicrinus elegans.** Post. **10. Cercidocrinus bursaeformis.** Post. **11a, b. Scytalocrinus validus.** Ant. views. **12. Eratocrinus elegans.** Post. **13, 14. Ulrichicrinus** spp. **13. U. coryphaeus.** Post. **14. U. oklahomae.** Post. **15a, b. Abrotocrinus unicus.** Ant. views.

1a

1b

2a

2b

3a

3b

4a

4b

4c

5a

5b

6

7

8

9a

9b

10

11

12

13a

13b

14

15

16

17

18

19a

19b

19c

20a

20b

21

22a

22b

22c

23a

23b

24a

24b

25a

25b

tinguished by form of cup and ornamentation (108). **Penn.: Tex.** (Palo Pinto).

***P. noduliferus** (M and G) [**62**—9, **64**—5]. Sides of cup evenly rounded; proximal parts of PBrBr flattened and strongly projecting, each Br bears a small node (92, 108). **Penn.:** Mo. (Missouri).

LASANOCRINUS Moore and Plummer 1940

(**Hydreionocrinus daileyi* Strimple). Cup very low, basal concavity shallow, characterized by downward or laterally directed prominences of the RR that approach or reach the basal plane of the cup; arms unknown (108). **Penn.** (Morrow).

***L. daileyi** (Strimple) [**63**—14]. RR strongly bulging outward and downward; surface granulose (108, 147). **Wapanucka, Brentwood:** Okla.

L. cornutus Moore and Plummer [**62**—6, **63**—15]. Prominences of the RR form spines that project below the plane of BB (108). **Marble Falls:** Tex.

UTHAROCRINUS Moore and Plummer 1938

(**Delocrinus pentanodus* Mather). Distinguished by spinous projections of BB (107). **Penn.** (Morrow–Virgil).

***U. pentanodus** (Mather) [**62**—13, **64**—18]. Cup very small; spines directed laterally and downward; X and RX above line of RR (107). **Brentwood:** Okla.

U. quinquacutus Moore [**62**—14, **64**—17]. Cup moderately high, spines pointed straight downward; three XX in cup (103). **Brownville:** Okla.

PLAXOCRINUS Moore and Plummer 1938

(**Hydreionocrinus crassidiscus* Miller and Gurley). Like *Perimestocrinus* but cup typically lower and basal concavity broader and shallower (107, 108). **Penn.** (Morrow–Virgil).

P. perundatus Moore and Plummer [**63**—9]. A large species; posterior interradius broad; PBrBr protuberant but not spinose (108). **Millsap Lake:** Tex.

P. obesus Moore and Plummer [**63**—8]. RR rather strongly convex, appearing swollen (108). **Millsap Lake:** Tex.

P. discus (Meek and Worthen) [**63**—6]. Surfaces of adjoining plates confluent (82). **Penn.:** Ill. (Missouri).

***P. crassidiscus** (M and G) [**62**—7; **63**—7]. Like *P. discus* but plates more convex, sutures somewhat impressed (92, 108). **Penn.:** Mo. (Missouri).

P. parilis Moore and Plummer [**63**—5]. Closely resembles *P. crassidiscus*; distinguished by shape of BB and RR (108). **Penn.:** Tex. (Graford).

P. virginarius Moore [**63**—2]. Outline of cup rounded, sides steep, sutures not impressed (103). **Penn.:** Okla. (Brownville).

P. politus Moore [**63**—1]. A small species; cup very low; PBrBr elongate, bearing short spines distally; rami branch once on SBr_{4-6} (103). **Penn.:** Okla. (Nelagoney)

P. praevalens Moore [**62**—5, **63**—16]. Cup unusually high; distinguished by large PBrBr that are produced laterally in a long spine (103). **Penn.:** Okla. (Brownville).

AATOCRINUS Moore and Plummer 1940

(**Zeacrinus? robustus* Beede). Like *Perimestocrinus* in having a sharply defined basal concavity but differs in attitude of RR, which form part of the basal concavity; wide notches between R facets (108). **Penn.** (Des Moines, Missouri).

***A. robustus** (Beede) [**62**—21, **63**—11]. Cup large, plates strongly convex; posterior interradius narrow, deeply indented (108). **Missouri:** Mo.

A. mucrospinus (McChesney) [**63**—3]. Surface confluent from BB to RR; PBrBr produced in long slender spines. **Des Moines:** Ill.

A. patulus (Girty) [**63**—4]. Proximal part of BB less steeply inclined than in other species (24). **Wewoka:** Okla.

A. mooresi (Whitfield) [**63**—10]. Closely resembles *A. mucrospinus* but distinguished by bulbous proximal part of PBrBr (110). **Penn.:** Ohio (Mercer), Kan. (Cherokee), Okla. (Savanna).

ATHLOCRINUS Moore and Plummer 1940

(**A. placidus*). Like *Plaxocrinus* but cup lower and base flat (108). **Penn.** (Des Moines, Missouri).

***A. placidus** M and P [**62**—1, **63**—13]. Slightly elongate anteroposteriorly, contour smooth, surface finely granulose (108). **Plattsburg:** Kan.

A. clypeiformis Moore and Plummer [**63**—12]. RR more bulbous than in *A. placidus* (108). **Merriman:** Tex.

LAUDONOCRINUS Moore and Plummer 1940

(**Hydreionocrinus subsinuatus* Miller and Gurley). Like *Athlocrinus* but cup higher, smoothly rounded (108). **Penn.** (Des Moines, Missouri).

PLATE 60

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1a, b. Abrotocrinus cymosus, type. Post. (Original by Moore and Laudon); ant. (91). **2a–c. Hylodecrinus sculptus** (72). Ant. (type), post. (type), right ant. **3a, b. Gilmocrinus iowensis** (74). Ant. showing anal opening (x2); lat. of another specimen. **4a, b. Hylodecrinus asper** (72), type. Post., ant. **5–7. Phacelocrinus spp. 5a, b. P. vanhornei** (191). Post. (type); post. of another specimen showing sac. **6. P. decabrachiatus** (37), type. Post. **7. P. dactyliformis** (37), type. Ant. **8–10. Hypselocrinus spp. 8. H. douglassi** (74) (x2). Post. **9a, b. H. maccabei** (78). Ant., post. **10. H. sansabensis** (108) (x2), type. Ant. **11. Eratocrinus serratus** (84). Post. **12. Decadocrinus spinulifer** (75), type. Right ant. **13a, b. Nebraskacrinus tourteloti** (103), type. Right ant.; post. **14. Stellarocrinus florealis** (108), type. Dorsal showing arm branching. **15. Stinocrinus manus** (91), type. Post. **16. Phacelocrinus internodius** (37), type. Ant. **17. Pachylocrinus globosus** (78). Ant. **18. Decadocrinus gregarius** (25) (x1.5), type. Lat. **19a, b. Stuartweilercrinus symmetricus** (108), types. Post., ventral, dorsal. **20a, b. Cercidocrinus infrequens** (78), type. Right ant., left post. **21. Hypselocrinus hoveyi** (85), type. Ant. **22a–c. Histocrinus coreyi** (85), types. Ant., post., and specimen with sac and anal opening. **23–25. Adinocrinus spp. 23a, b. A. compactilis** (84), type. Dorsal, lat. **24a, b. A. pentagonus** (91), type. Post., dorsal. **25a, b. A. nodosus** (162), type. Dorsal, lat.

1a

1b

1c

1d

1e

1f

1g

2a

2b

3

4

5a

5b

6

7a

7b

8a

8b

9a

9b

10

11a

11b

11c

12a

12b

13a

13b

14a

14b

15a

15b

***L. subsinuatus** (M and G) [**62**—10, **64**—10]. Outline of cup hexagonal, no notches between R facets (92, 108). **Missouri:** Mo.

L. catillus Moore and Plummer [**64**—9]. Notches between R facets (108). **Penn.:** Okla. (Oologah), Tex. (Millsap Lake).

PIRASOCRINUS Moore and Plummer 1940

(**P. scotti*). Cup very low, characterized by deep basal concavity, IBB and BB not visible from side; PBr_1 axillary, isotomous divisions of rami at uniform heights, AxAx bulbous; anal sac reaching above arm tips, capped by plates bearing laterally directed spines; stem round (108). **Penn.** (Des Moines).

***P. scotti** M and P [**62**—18, **63**—23]. BrBr quadrate, short (108). **Millsap Lake:** Tex.

SCHISTOCRINUS Moore and Plummer 1940

(**S. torquatus*). Like *Laudonocrinus* but having prominent IB circlet, deeply indented by stem impression, and BB much reduced, not in lateral contact; anal sac mushroom-shaped, bordered at top by laterally directed spines; PBr_1 axillary, may be six isotomous divisions in a ray (108). **Penn.** (Des Moines, Missouri).

S. parvus Moore and Plummer [**64**—27]. A small species; three divisions in ray (108). **Millsap Lake:** Tex.

S. confertus Moore and Plummer [**64**—32]. Cup discoid; large anal sac; five to six divisions of arms (108). **Millsap Lake:** Tex.

***S. torquatus** M and P [**62**—12, **64**—8]. Sides of cup flaring upward evenly; prominent projection of XX above cup (108). **Winterset:** Mo.

SCIADIOCRINUS Moore and Plummer 1938

(**Zeacrinus* (*Hydreionocrinus*) *acanthophorus* Meek and Worthen). Like *Pirasocrinus* but crown much shorter, basal concavity of cup shallower, SBrBr and TBrBr fewer, AxAx not bulbous, and anal sac more prominent (107, 108). **Penn.** (Des Moines, Missouri).

***S. acanthophorus** (M and W) [**62**—11, **64**—1]. A small species; RA very elongate, touching RPIB; length of BrBr about equal to width (84, 107). **Des Moines:** Ill.

S. harrisae Moore and Plummer [**62**—17, **64**—6]. RR very prominent, bulbous (108). **Penn.:** Okla. (Oologah), Tex. (Millsap Lake).

S. disculus Moore and Plummer [**64**—7]. Basal concavity of cup broad, shallow; sutures not impressed (108). **Mineral Wells, Graford:** Tex.

GALATEACRINUS Moore 1940

(**G. stevensi*). Cup very low, discoid, base concave; B and R circlets sharply differentiated, RR much thickened and projecting laterally; R facets nearly horizontal, denticles prominent on outer ligament-area; stem round (104). **Penn.** (Des Moines–Virgil).

***G. stevensi** Moore [**62**—2, **64**—15]. Surface ornamented by strongly marked ridges and tubercles (104). **Oologah:** Okla.

G. allisoni Moore [**64**—13]. Like *G. stevensi* but surface smooth (104). **Iola:** Kan.

G. ewersi Moore [**64**—14]. Like *G. allisoni* but RR slope steeply downward from edges of facets (104). **Graford:** Tex.

ZEACRINITIDAE [**52**—13]. Dicyclic; like Pirasocrinidae except for arm structure; BrBr uniserial or biserial, branching endotomously, suture between R and PBr not gaping. **Miss.–Perm.**

ZEACRINITES Troost 1858

(**Cyathocrinus magnoliaeformis* Owen and Norwood). Crown ovoid; cup very low; BB elongate, forming an important part of basal concavity of cup; thick XX attached to cup, projecting above RR; anal sac pyramidal, not elongate; arms closely appressed, PBr_1 axillary in all rays except anterior; stem round (65, 108, 140, 152). **Miss., ?Penn.**

***Z. magnoliaeformis** (O and N) [**61**—1]. BB large; RA elongate, typically followed by four XX that form upward projection; two PBrBr in anterior ray, arms long (140). **Miss.:** Ala. (Gasper).

Z. wortheni (Hall) [**61**—2]. Differs from *Z. magnoliaeformis* in having lower crown, shallower basal concavity, smaller BB, and more numerous rami (140). **Miss.:** Ky. (Glen Dean).

Z.? sellardsi Moore and Plummer [**63**—17]. RA resting on tip of PB, followed by X and RX; surface granulose; arms unknown (108). **Penn.:** Tex. (Graford).

ERATOCRINUS Kirk 1938

(**Zeacrinus elegans* Hall). Like *Zeacrinites* but crown pear-shaped, cup less depressed, R facets more nearly horizontal, BB and RA less elongate, and arms longer and more slender (65). **Miss.** (Kinderhook, Osage).

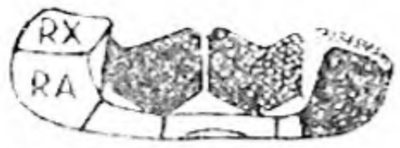
***E. elegans** (Hall) [**59**—12, **61**—13]. BrBr very short, quadrate, anterior arm branches on PBr_2 (140). **U. Burlington:** Ia.

E. commaticus (S. A. Miller) [**61**—3]. Anal sac club-shaped, reaching to arm tips, nodose plates at

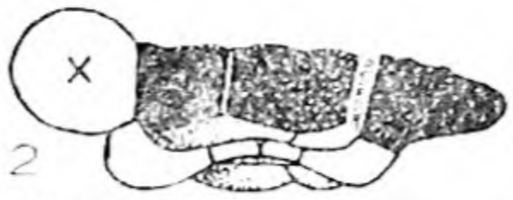
PLATE 61

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1, 2. Zeacrinites spp. 1a–f. Z. magnoliaeformis (140). Ant., dorsal, ventral, post., two dorsals. **2a–c. Z. wortheni** (140). Post., dorsal, ant. **3. Eratocrinus commaticus** (140). Post. **4. Dasciocrinus florealis** (140). Crown showing distal end of sac. **5–9. Agassizocrinus spp. 5a, b. A. gibbosus** (140). Post., ant. **6. A. globosus** (140). Post. **7a, b. A. conicus** (140). Type and another specimen. **8a, b. A. laevis** (140). Post. of specimen; post. of type. **9a, b. A. ovalis** (140). Ant., post. **10. Pachylocrinus aequalis** (140). Post. **11a–c. Anartiocrinus maxvillensis** (140). Post., ant. **12a, b. Dinotocrinus compactus** (73), type. Ant., post. **13a, b. Eratocrinus elegans** (140). Ant., post. **14a, b. Aulocrinus agassizi** (140), Lat., post. **15a, b. Alcimocrinus girtyi** (140), type. Post., ant.



Stylocrinus placidus
1

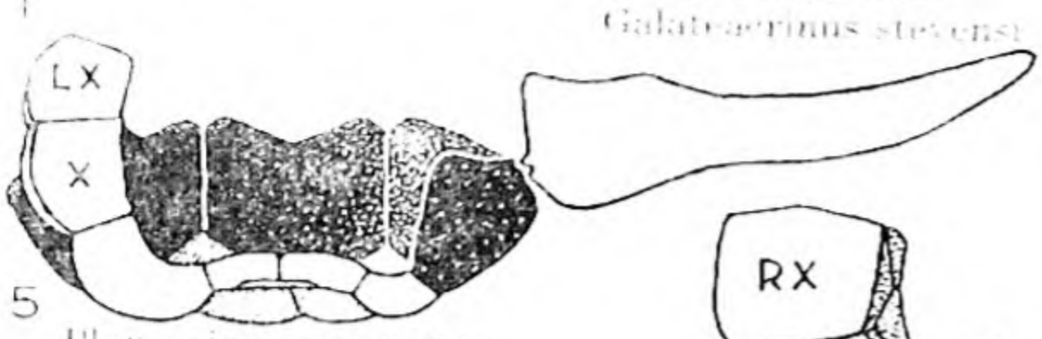


2 Galateacrinus stevensi

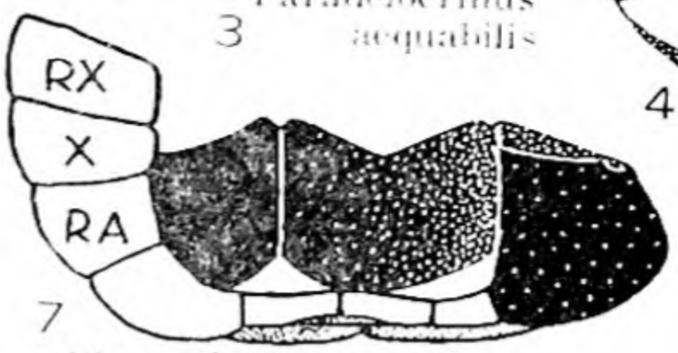
62

3 Paradelocrinus aequabilis

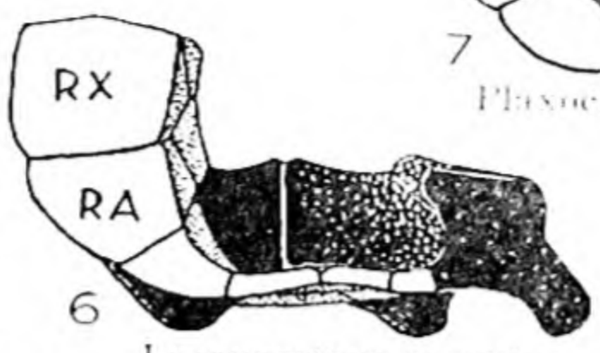
4 Adinocrinus nodosus



5 Planocrinus praevalens

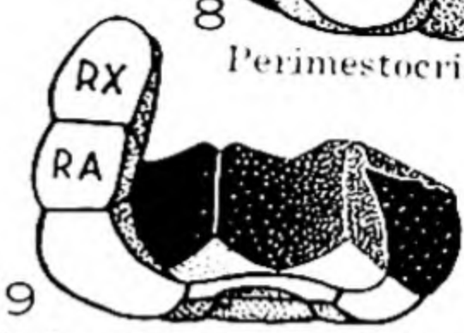


7 Plaxocrinus crassidiscus

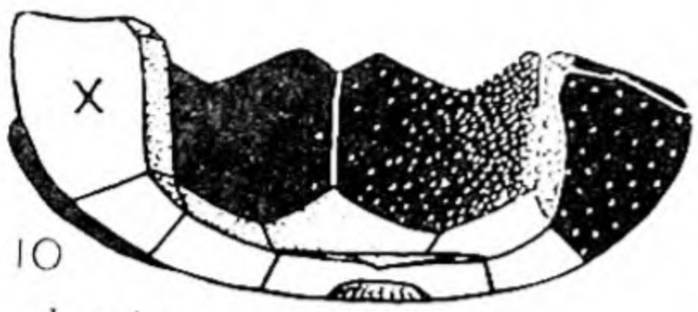


6 Lasanocrinus cornutus

8 Perimestocrinus impressus

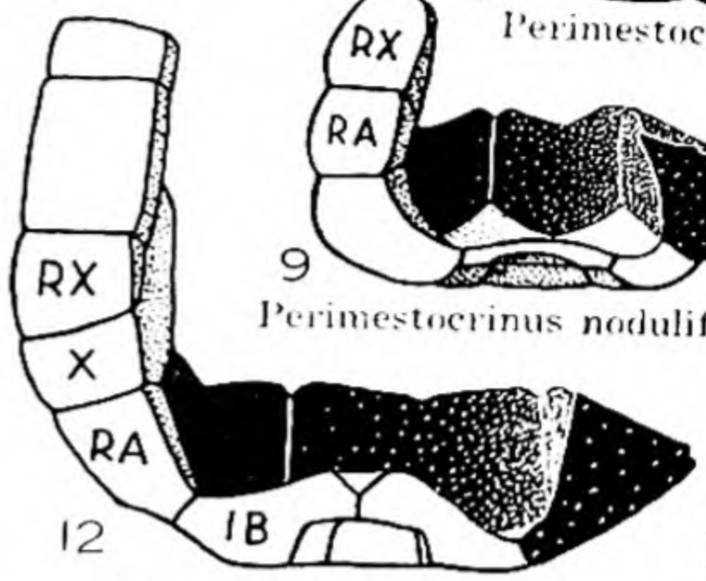


9 Perimestocrinus noduliferus



10 Landonocrinus subsimuatus

11 Sciadiocrinus acanthophorus



12 Schistocrinus torquatus

13

Utharocrinus pentanodu

14 Utharocrinus quinquacutus

15 Neozeacrinus uddeni

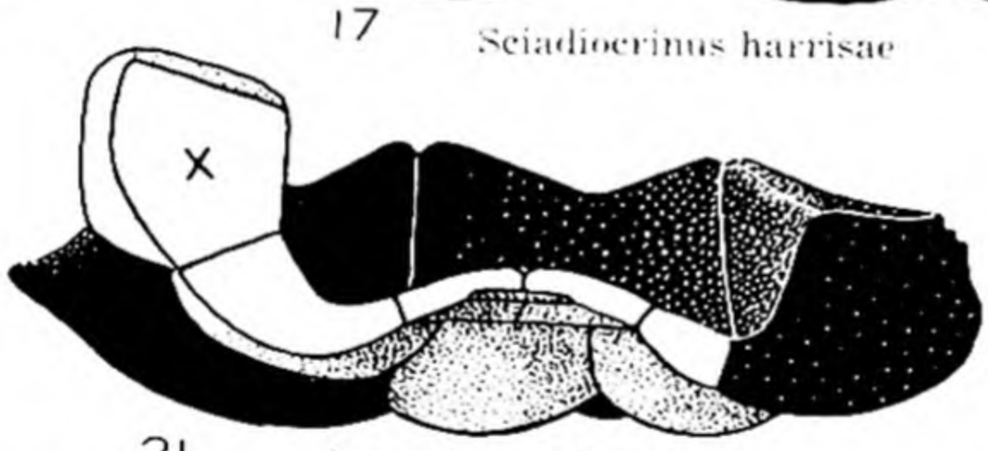
16 Cibolocrinus banioni

17 Sciadiocrinus harrisae

18 Pirasocrinus scotti

19 Oklahomacrinus supinus

Endelocrinus fayettensis
20



21 Aatocrinus robustus

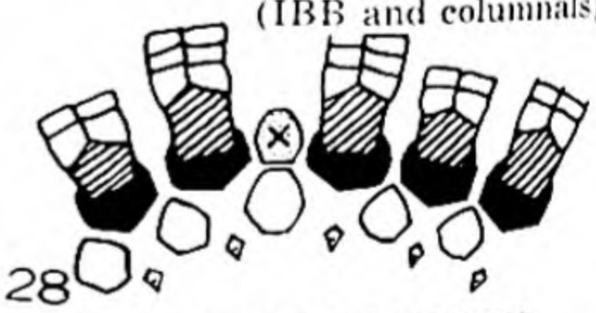
22 Apographiocrinus typicalis

23 Elibatocrinus leptocalyx (IBB and columnals)

24 Delocrinus missouriensis

25 DELOCRINUS

26 ERISOCRINUS


28 APOGRAPHIOCRINUS

30 Delocrinus subhemisphericus

27 Erisocrinus typus

31 Paradelocrinus dubius

29 Plummericrinus meguirei

32 Aesiocrinus magnificus

33 Delocrinus abruptus

34 Paradelocrinus brachiatus

35 Pachylocrinus ogarai

summit; four PBrBr in anterior arm (140). **Keokuk:** Mo.

E. serratus (Meek and Worthen) [**60**—11]. A small species; BrBr keeled (84). **Burlington:** Ia.

LINOCRINUS Kirk 1938

(**L. wachsmuthi*). Like *Zeacrinites* but distinguished by average small size, rugosity of plates, gaping suture between R and PBr, less firm union of XX to form projection on posterior side of cup, and recurved form of anal sac; PBr_1 axillary except in anterior ray, which has 3 to 11 PBrBr (65). **Miss.** (Kinderhook–Chester).

L. compactus (Laudon) [**64**—23]. Anterior arm has three PBrBr, six or seven bifurcations in each ray; plates nodose (74). **Gilmore City:** Ia.

L. penicillus (Meek and Worthen) [**64**—20]. Anterior arm has six PBrBr, typically three bifurcations in each ray (84). **Burlington:** Ia.

L. asper (Meek and Worthen) [**64**—19]. Distinguished by uneven projections of BrBr; three bifurcations to ray (84). **Burlington:** Ia.

L. scobina (Meek and Worthen) [**64**—24]. Anterior arm has 11 PBrBr, all plates strongly keeled (84). **Burlington:** Ia.

L. praemorsus (Miller and Gurley) [**64**—22]. Anterior arm has five PBrBr, three or four bifurcations in each ray (91). **Keokuk:** Ind.

***L. wachsmuthi** Kirk [**59**—3]. Cup very low, plates strongly rugose; five PBrBr in anterior ray (65). **Chester:** Ala.

L. arboreus (Worthen) [**59**—5]. Like *L. wachsmuthi* but cup higher, plates less rugose and arms stouter (65, 140). **Chester:** Ala.

THOLOCRINUS Kirk 1939

(**Hydreionocrinus spinosus* Wood). Like *Linocrinus* but has mushroom-shaped anal sac that bears laterally directed spines, plates smooth, and arms biserial or nearly biserial (66). **Miss.** (Chester).

***T. spinosus** (Wood) [**59**—2]. Arms slender, about six bifurcations in ray, PBr_1 of anterior ray not axillary (66, 140). **Glen Dean:** Ky.

T. wetherbyi (Wachsmuth and Springer) [**59**—4]. Arms stout, three bifurcations in ray, PBr_1 of anterior ray axillary (140). **Glen Dean:** Ky.

ALCIMOCRINUS Kirk 1938

(**Zeacrinus girtyi* Springer). Like *Zeacrinites* but two PBrBr in each ray and anal sac tall, club-shaped (65). **Penn.** (Morrow).

***A. girtyi** (Springer) [**61**—15]. Exceptional development of endotomous branching, eight or nine bifurcations to ray (140). **Morrow:** Okla.

NEOZEACRINUS Wanner 1937 [**52**—13]

(**N. peramplus*). Crown broadly ovoid; cup very low, basal concavity shallow; arms divide isotomously on PBr_1 in all rays and each main ramus branches endotomously, giving a bi-endotomous structure in each ray, four pinnules to each Br (108, 168). **Penn., Perm.**

N. praecursor Moore and Plummer [**63**—21]. Sutures between plates of cup not strongly impressed; arms relatively slender (108). **Penn.:** Tex. (Millsap Lake).

N. uddeni (Weller) [**62**—15, **63**—22]. Sutures between plates strongly impressed; RA touches RPIB; arms unknown (108, 174). **Perm.:** Tex. (Cibolo).

Other genus: *Sarocrinus* Kirk 1942.

AMPELOCRINIDAE. Dicyclic; crown umbrella-like, arms spreading laterally or pendent; cup truncate bowl-shaped; IBB five, not visible from side; R facets wide, sloping inward, transverse ridge prominent; one X in cup; arms uniserial; stem pentagonal. **Miss., Penn.**

AESIOCRINUS Miller and Gurley 1890

(**A. magnificus*). Cup like that of *Delocrinus* but lacking basal concavity; arms typically branching on PBr_2, rami undivided but in some, branching also on SBr_2, or arms atomous; prominent anal sac composed of vertical series of plates (91). **L. Carb.** (Scotland), **Penn.**

***A. magnificus** M and G [**56**—32, **62**—32]. A relatively large species; arms long, 10 rami in crown (91). **Lane:** Mo.

OKLAHOMACRINUS Moore 1939

(**O. supinus*). Like *Aesiocrinus* but cup much lower, pentagonal in outline; X narrow and elongate; PBrBr two in each ray, partly fused; arms pendent (103). **Penn.** (Missouri, Virgil).

***O. supinus** Moore [**56**—24, **62**—19]. Cup relatively large; BB tumid; RR thick (103). **Brownville:** Okla.

O. loeblichi Moore [**56**—25]. Cup flatter than *O. supinus*; flangelike borders on RR and BrBr (103). **Francis:** Okla.

Other genus: *Ampelocrinus* Kirk 1942.

SCYTALOCRINIDAE [**52**—17]. Dicyclic; cup conical or semi-ovoid, IBB generally plainly visible from side; R facets wide, sloping gently outward, transverse ridge and ligament-areas distinctly marked; three XX in cup; sac cylindrical, weak; arms uniserial, in most genera branching isotomously on PBr_1, or PBr_2, making 10 rami, pinnulate. **Dev.–Perm.**

COREMATOCRINUS Goldring 1923

(**C. plumosus*). Cup steeply conical; PBrBr two in each ray, may be completely or partly fused, rami

PLATE 62

Antero-posterior cross sections of the dorsal cups of Cladoidea and a section, oblique to this axis, of a flexible crinoid (*Cibolocrinus*, 16); and plate analyses of *Delocrinus* (25), *Erisocrinus* (26), and *Apographiocrinus* (28).

1a 1b 1c 2a 2b 2c 3 4a 4b 4c 5a-d 6a 6b 7a 7b 8a 8b 8c 8d 9a 9b 9c 9d 10a 10b 10c,d 11a 11b 11c 12a-d 13a-d 14a 14b 14c 15a 15b 16a 16b 17a 17b 17c 18a 18b 19a 19b 20a 20b 20c 20d 20e 21a 21b 22a 22b 23a 23b

10, rounded, one pinnule to each Br; stem pentagonal (25). **U. Dev.**

***C. plumosus** Goldring [58—7]. Slender rami bearing long delicate pinnules (25). **Portage:** N. Y.

LOGOCRINUS Goldring 1923

(**L. geniculatus*). Differs from *Corematocrinus* in having one pinnule to each second Br and round stem (25). **U. Dev.**

***L. geniculatus** Goldring [58—1]. Rami have slightly zigzag form (25). **Hamilton:** N. Y.

L. infundibuliformis Goldring [58—13]. Rami straight (25). **Chemung:** N. Y.

SCYTALOCRINUS Wachsmuth and Springer 1879

(**Scaphiocrinus robustus* Hall). Cup truncate cone-shaped, IBB low, not strongly upflaring; arms branch isotomously on PBr, rami short, stout, round and smooth, one pinnule to each Br; stem round (162). **Dev., Miss.**

S. validus Wachsmuth and Springer [59—11]. Rami very stout, SBrBr short (140). **Miss.:** Ind. (Keokuk).

DECADOCRINUS

Wachsmuth and Springer 1879 [52—17]

(**Poteriocrinus* (*Scaphiocrinus*) *scalaris* Meek and Worthen). Like *Scytalocrinus* except for strongly cuneate shape of SBrBr, relatively larger pinnules, and IBB may not be visible from side; some species have two PBrBr in each arm; stem round or pentagonal (162). **Dev.–Penn.**

D. nereus (Hall) [64—16]. RR partly separated from adjoining plates of this circlet; PBrBr two in each ray, SBrBr elongate (25). **Dev.:** N. Y. (Hamilton).

D. gregarius Williams [60—18]. Like *D. nereus* but much smaller (25). **Dev.:** N. Y. (Chemung).

D. spinulifer Laudon [60—12]. Plates of cup nodose; rami long, slender, relatively smooth, PBrBr two in each ray (75). **Dev.:** Ia. (Cedar Valley).

D. halli (Hall) [59—8]. PBrBr one in each ray, SBrBr very uneven (140). **Miss.:** Ia. (U. Burlington).

D. repertus (Miller and Gurley) [64—26]. Like *D. halli* but SBrBr more even (91). **Miss.:** Ind. (Keokuk).

D. bellus (Miller and Gurley) [64—25]. A robust species; resembles *D. halli* but plates of cup ridged and SBrBr less uneven (91). **Miss.:** Ind. (Keokuk).

D. tumidulus (Miller and Gurley) [59—7]. A very robust form; arms branching on PBr_2, more rounded than in *D. halli*, pinnules more widely spaced (92). **Miss.:** Ind. (Keokuk).

GILMOCRINUS Laudon 1933

(**G. iowensis*). Arms generally unbranched, but one of them may divide on PBr_1 (74). **Miss.** (Kinderhook).

***G. iowensis** Laudon [60—3]. Anal sac tall, plates bordered by prominent slits, a spine or spines at top (74). **Hampton:** Ia.

HYPSELOCRINUS Kirk 1940

(**Poteriocrinus hoveyi* Worthen). Like *Scytalocrinus* but cup more steeply conical, rami typically longer and more slender, and arm of AR commonly undivided; stem round (71). **Miss., Penn.**

H. maccabei (Miller and Gurley) [60—9]. Crown very slender, small; SBrBr uneven (78). **Miss.:** Ia. (Hampton).

H. douglassi (Miller and Gurley) [60—8]. Like *H. maccabei* but smaller; SBrBr very elongate (74). **Miss.:** Ia. (Gilmore City).

***H. hoveyi** (Worthen) [60—21]. Rami very long, slender (85). **Miss.:** Ind. (Keokuk).

H. arcanus (Miller and Gurley) [58—17]. Like *H. hoveyi* but smaller and arms shorter (91). **Miss.:** Ind. (Keokuk).

H. sansabensis (Moore and Plummer) [60—10]. A small species closely resembling *H. arcanus* (107). **Penn.:** Tex. (Marble Falls).

H.? macoupinensis (Worthen) [57—19]. Cup like that of *H. sansabensis* but larger; arms unknown (84). **Penn.:** Ill. (Des Moines).

H.? lasallensis (Worthen) [57—17]. Cup somewhat bowl-shaped, plates moderately angulated; R facets wide, arms unknown (85). **Penn.:** Ill. (Missouri).

HISTOCRINUS Kirk 1940

(**Poteriocrinus coreyi* Worthen). Like *Hypselocrinus* but two PBrBr in each ray except anterior, which lacks division (71). **Miss.** (Osage).

***H. coreyi** (Worthen) [60—22] (85). **Keokuk:** Ind.

PLATE 63

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1, 2. Plaxocrinus spp. 1a–c. P. politus (103), type. Ant., post., dorsal. **2a–c. P. virginarius** (103), type. Dorsal, post., ventral. **3, 4. Aatocrinus spp. 3. A. mucrospinus** (after McChesney), type. Dorsal. **4a–c. A. patulus** (24) (x2), type. Dorsal, ant., ventral. **5–9. Plaxocrinus spp. 5a–d. P. parilis** (108), type. Post., dorsal, ventral, ant. **6a, b. P. discus** (84), type. Dorsal, post. **7a, b. P. crassidiscus** (108), type. Post., dorsal. **8a–d. P. obesus** (108), type. Ant., post., ventral, dorsal. **9a–d. P. perundatus** (108), type. Post., dorsal, ventral, ant. **10, 11. Aatocrinus spp. 10a–d. A. mooresi** (186), type. Post., dorsal, PBr spines. **11a–c. A. robustus** (108), type. Dorsal, post., ventral. **12, 13. Athlocrinus spp. 12a–d. A. clypeiformis** (108), type. Post., dorsal, ventral, ant. **13a–d. A. placidus** (108), type. Post., dorsal, ventral, ant. **14, 15. Lasanocrinus spp. 14a–c. L. dalleyi** (108), type. Dorsal, ventral, post. **15a, b. L. cornutus** (108), type. Post., dorsal. **16a, b. Plaxocrinus praevalens** (103), type. Post., dorsal. **17a–c. Zeacrinites? sellardsi** (108), type. Post., dorsal, ventral. **18–20. Plummericrinus spp. 18a, b. P. uddeni** (108), type. Post., dorsal. **19a, b. P. ogarai** (108), type. Post., dorsal. **20a–e. P. mcguirei** (103), type. Ant., post., dorsal, crown, ventral. **21, 22. Neozeacrinus spp. 21a, b. N. praecursor** (108), types. Dorsal, post. **22a, b. N. uddeni** (108), type. Dorsal, post. **23a, b. Pirasocrinus scotti** (108), types. Dorsal, post.

1a 1b 1c 1d 7b 7a 6a 6b 8a 8b 8c 9a 9b 17a 17b 17c 13a 13b 15a 15b 14a 14b 15c 15d 16a 16b 2a 2b 3a 3b 3c 10a 10b 11a-c 18a 18b 19 4a 4b 5a 5b 12a 12b 21a 20 21b 22 23 24 21c 29b 29c 29a 30 35b 35a 37a 37b 36c 36b 36a 34a 34b 33c 33a 33b 31a 31b 32 28a 28b 28c 27a 27b 26a 26b 25

PHACELOCRINUS Kirk 1940

(*Poteriocrinus wetherbyi* Miller). Like *Histocrinus* but two PBrBr in anterior ray, or all PBrBr partly fused, sutures between RR and PBrBr gaping; stem pentagonal (71). **Miss.** (Meramec, Chester).

P. dactyliformis (Hall). [**60**—7]. BrBr strongly cuneate, some rami may show an isotomous division (37). **St. Louis:** Mo.

P. vanhornei (Worthen) [**60**—5]. Crown slender; anal sac tall, cylindrical (85). **St. Louis:** Ill.

P. decabrachiatus (Hall) [**60**—6]. PBrBr fused, rami shorter than in *P. vanhornei* (37). **Chester:** Ill.

P. internodius (Hall) [**60**—16]. A small species; PBrBr elongate (37). **Chester:** Ill.

AULOCRINUS Wachsmuth and Springer 1897

(**A. agassizi*). Cup truncate cone-shaped, base depressed, IBB not visible from side; arms like those of *Decadocrinus*, PBrBr one in each ray; anal sac bears a prominent lateral spout (140). **Miss.**

***A. agassizi** W and S [**61**—14]. Plates of cup ridged; BrBr of rami uneven (140). **Keokuk:** Ind.

Other genus: *Morrowcrinus* Moore and Plummer 1938 (107).

ERISOCRINIDAE. Dicyclic; crown subcylindrical; cup low, truncate conical or bowl-shaped, typically marked by a basal concavity; IBB not visible from side; R facets wide, as in Zeacrinitidae but nearly horizontal; XX in cup, three to none but typically one; arms unbranched or divided isotomously once, on PBr_1, uniserial or biserial; stem round, **Miss.–Trias.**

PENTARAMICRINUS
Sutton and Winkler 1940

(**Cromyocrinus gracilis* Wetherby). Cup low bowl-shaped, circular in outline, surface smooth, base concave; three XX in cup; arms undivided, long, uniserial, BrBr short, quadrate (153). **Miss.** (Chester).

***P. gracilis** (Wetherby) [**64**—30] (153). **Chester:** Ky., Ill. (Golconda).

PHANOCRINUS Kirk 1937

(**Zeacrinus formosus* Worthen). Like *Pentaramicrinus* but arms dividing isotomously on PBr_1 (64, 153). **Miss.** (Chester).

***P. formosus** (Worthen) [**65**—32]. Sides of cup slightly constricted toward top; sutures moderately impressed (64). **Glen Dean:** Ky.

P. nitidus (Miller and Gurley) [**64**—35]. Crown much shorter than that of *P. formosus*; BrBr somewhat cuneate (153). **Chester:** Ill.

GRAPHIOCRINUS Koninck and LeHon 1854

(**G. encrinoides*). Like *Phanocrinus* but only one X in cup, resting on truncate tip of PB (128). **Miss.–Perm.**

G. kingi Moore and Plummer [**65**—18]. BrBr slightly cuneate, width twice length; surface granulose (108). **Penn.:** Tex. (Mineral Wells).

DELOCRINUS Miller and Gurley 1890 [**62**—25]

(**Poteriocrinus hemisphericus* Shumard). Like *Graphiocrinus* but BrBr above SBr arranged biserially; basal concavity of cup steep-sided and deep (108). **Miss.?** (Chester)**–Perm.**

D. matheri Moore and Plummer [**65**—11]. A small species; cup very low; surface ornamented by fine irregular ridges (107). **Penn.:** Okla. (Brentwood).

D. granulosus Moore and Plummer [**65**—13]. Surface granulose and marked by low rounded tubercles (108). **Penn.:** Okla. (Wewoka), Tex. (Mineral Wells).

D. somersi (Whitfield) [**65**—15]. Like *D. granulosus* but smaller and granules coarser (186). **Penn.:** Ohio. (Pottsville).

D. bispinosus Moore and Plummer [**65**—8]. Surface smooth except for tubercles at upper corners of RR (108). **Penn.:** Tex. (Mineral Wells).

D. benthobatus Moore and Plummer [**65**—29]. Crown constricted above PBrBr, rami thickest at midheight (108). **Penn.:** Tex. (Mineral Wells).

D. pictus Moore and Plummer [**65**—12]. Surface ornamented by closely spaced large granules (108). **Penn.:** Tex. (Graford).

D. papulosus Moore and Plummer [**65**—26]. Like

PLATE 64

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1a–d. Sciadiocrinus acanthophorus (84), type. Ant. showing anal opening, dorsal, post., top of sac. **2–5. Perimestocrinus** spp. **2a, b. P. calyculus** (108), type. Post., dorsal. **3a–c. P. formosus** (108), type. Post., dorsal, ventral. **4a, b. P. pumilis** (107), type. Post., dorsal. **5a, b. P. noduliferus** (108) (x2), type. Dorsal, post. **6, 7. Sciadiocrinus** spp. **6a, b. S. harrisae** (108), type. Post., dorsal. **7a, b. S. disculus** (108), type. Dorsal, post. **8a–c. Schistocrinus torquatus** (108), type. Dorsal, ant., post. **9, 10. Laudonocrinus** spp. **9a, b. L. catillus** (108), type. Post., dorsal. **10a, b. L. subsinuatus** (108), type. Post., dorsal. **11, 12. Perimestocrinus** spp. **11a–c. P. teneris** (107), type. Post., dorsal, ant. **12a, b. P. impressus** (108), type. Post., dorsal. **13–15. Galateacrinus** spp. **13a, b. G. allisoni** (104), type. Post., ventral. **14a, b. G. ewersi** (104) (x2), type. Post., dorsal. **15a–d. G. stevensi** (104) (x2), type. Post., dorsal, ventral, ant. **16a, b. Decadocrinus nereus** (25). Dorsal (x2), lat. **17, 18. Utharocrinus** spp. **17a–c. U. quinquacutus** (103), type. Post., dorsal, ventral. **18a, b. U. pentanodus** (107) (x2.5), type. Post., dorsal. **19, 20. Linocrinus** spp. **19. L. asper** (84), type. Lat. view of crown. **20. L. penicillus** (84), type. Post. **21a–c. Pachylocrinus lacunosus** (91), type. Dorsal, ant., post. **22–24. Linocrinus** spp. **22. L. praemorsus** (91), type. Ant. **23. L. compactus** (74), type. Ant. **24. L. scobina** (84), type. Lat. view of crown. **25, 26. Decadocrinus** spp. **25. D. bellus** (91), type. Post. **26a, b. D. repertus** (01), type. Ant., post. **27a, b. Schistocrinus parvus** (108), type. Ant. showing projecting spines of sac; post. **28a–c. Eupachycrinus spartarius** (64). Ant., post., dorsal. **29a, b. Sellardsicrinus marrsae** (108), type. Lat. view of crown; arms. **30. Pentaramicrinus gracilis** (64). type. Post. **31a, b. Parulocrinus pustulosus** (108), type. Post., dorsal. **32. Schistocrinus confertus** (108), type. Ant. **33, 34. Eupachycrinus** spp. **33a–c. E. quatuordecimbrachialis** (64), type. Post., dorsal, ant. **34a, b. E. asperatus** (153), type. Post., ant. **35a, b. Phanocrinus nitidus** (153), type. Post., ant. **36, 37. Parulocrinus** spp. **36. P. compactus** (108). Post., dorsal, ventral (immature). **37a, b. P. blairi** (108), type. Post., dorsal.

1a 1b 1c 2a 2b 2c 3a 3b 4a 4b 5a 5b 5c 6a 6b 6c 7a 7b 7c 7d 8a 8b 9a 9b 10a 10b 11a 11b 11c 12 13a 13b 13c 13d 14a 14b 15 16a 16b 17a 17b 18a 18b 18c 19a 19b 19c 20a 20b 20c 20d 21a 21b 22a 22b 22c 23a 23b 23c 24a 24b 25 26 27a 27b 28a 28b 29 30a 30b 31a 31b 31c 32a 32b 33a 33b

D. pictus but granules sparse (108). **Penn.:** Tex. (Graford).

D. graphicus Moore and Plummer [**65**—16]. Like *D. pictus* but granules finer (108). **Penn.:** Tex. (Graford).

D. verus Moore and Plummer [**65**—6]. Surface smooth, cup moderately high (108). **Penn.** (Missouri): Kan. (Winterset), Tex. (Palo Pinto).

D. missouriensis Miller and Gurley [**62**—24, **65**—14]. Like *D. verus* but differs in shape of cup (108). **Penn.** Mo. (Missouri).

D. subhemisphericus Moore and Plummer [**62**—30, **65**—7]. Like *D. verus* but larger and differs in shape of cup (108). **Penn.:** Mo. (Lane).

D. vulgatus Moore and Plummer [**65**—19]. Almost indistinguishable from *D. verus* (108). **Penn.:** Okla. (Brownville), Tex. (Harpersville).

D. abruptus Moore and Plummer [**62**—33, **65**—17]. Cup high, steep-sided, surface smooth (108). **Perm.:** Kan. (Beattie), Tex. (Moran).

D. quadratus Moore and Plummer [**65**—9]. Basal concavity broad, outline of cup quadrate in side view (108). **Perm.:** Tex. (Cibolo).

ENDELOCRINUS Moore and Plummer 1940

(**Eupachycrinus fayettensis* Worthen). Like *Delocrinus* but uniformly smaller, basal concavity shallower, depressions along sutures and small pits at angles between plates; BrBr uniserial in lower half of rami, biserial in upper half (108). **Penn., Perm.**

***E. fayettensis** (Worthen) [**62**—20, **65**—4]. Plates moderately convex; PBrBr elongate, not spinose (108). **Penn.:** Ill. (Missouri).

E. allegheniensis (Burke) [**65**—5]. Plates strongly convex; PBrBr produced in long spine (18). **Penn.** (Conemaugh): Pa., W. Va.

E. parvus Moore and Plummer [**65**—1]. Resembles *E. allegheniensis* but much smaller (108). **Penn.:** Tex. (Mineral Wells).

E. grafordensis Moore and Plummer [**65**—3]. Pits at angles between plates but sutures only slightly impressed; PBrBr not spinose (108). **Penn.:** Kan. and Okla. (Stanton), Tex. (Graford).

E. bifidus Moore and Plummer [**65**—2]. A very small species; RR marked by pairs of low knobs (108). **Penn.:** Tex. (Graford).

E. texanus (Weller) [**65**—10]. Largest described species; basal concavity broad (108, 174). **Perm.:** Tex. (Cibolo).

PARADELOCRINUS Moore and Plummer 1938

(**P. aequabilis*). Like *Delocrinus* but lacks X in cup (107). **Penn.** (Morrow-Virgil).

P. dubius (Mather) [**62**—31, **65**—21]. Basal concavity very deep; BB transversely concave (107). **Brentwood:** Ark., Okla.

***P. aequabilis** M and P [**62**—3, **65**—20]. Cup small, very low; surface ornamented by fine ridges (107). **Brentwood:** Ark.

P. planus (White) [**65**—24]. Like *Delocrinus missouriensis* but lacks X in cup (178). **Virgil:** Kan.

P. brachiatus Moore and Plummer [**62**—34, **65**—25]. Crown very tall, slender; cup of medium height; surface smooth (108). **Millsap Lake:** Tex.

P. obovatus Moore and Plummer [**65**—22]. Cup distinctly pentagonal in outline, concavity moderately deep (108). **Graford:** Tex.

P. protensus Moore and Plummer [**65**—23]. Like *P. obovatus* but sutures impressed (108). **Graford:** Tex.

ERISOCRINUS

Meek and Worthen 1865 [**62**—26]

(**E. typus*). Cup truncate conical, base flat, pentagonal in dorsal or ventral view; no X in cup (82, 84). **Penn., Perm.**

***E. typus** M and W [**62**—27, **65**—28]. Slope of sides of cup about 60° from basal plane (82). **Penn.:** Ill. (Missouri).

E. elevatus Moore and Plummer [**65**—27]. Slope of sides of cup about 75° from basal plane (108). **Palo Pinto:** Tex.

Other genera: *Diphuicrinus* Moore and Plummer 1938 (107), *Euerisocrinus* Strimple 1939 (145).

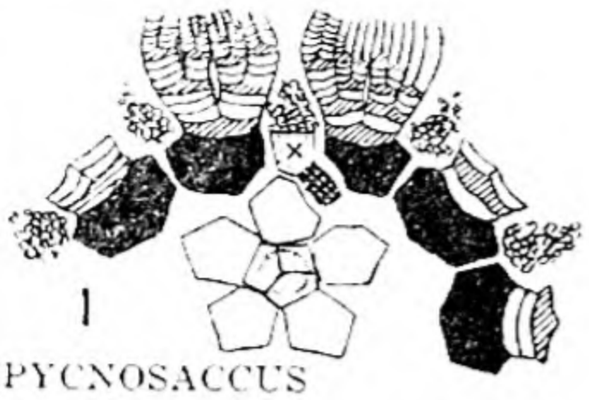
SPANIOCRINIDAE. Dicyclic; cup conical; IBB five to three, visible from side; R facets wide, having transverse ridge and ligament pits, plane subhorizontal; X in line with RR or absent from cup; anal sac unknown; arms undivided or branching isotomously on PBr_1. **?Miss., Perm.**

PLATE 65

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1–5. Endelocrinus spp. 1a–c. E. parvus (108), type. Dorsal, ventral, post. **2a–c. E. bifidus** (108) (x2), type. Dorsal, ventral, post. **3a, b. E. grafordensis** (108), type. Post., ant. **4a, b. E. fayettensis** (108), type. Left-oblique (x1.35), dorsal. **5a–c. E. allegheniensis** (18) (x2), type. Dorsal, ventral, post. **6–9. Delocrinus spp. 6a–c. D. verus** (108), type. Post., dorsal, ventral. **7a–d. D. subhemisphericus** (91, 108), types. Post., dorsal, ventral, ant. **8a, b. D. bispinosus** (108), type. Ant., dorsal. **9a, b. D. quadratus** (108), type. Left post., dorsal. **10a, b. Endelocrinus texanus** (108), type. Dorsal, post. **11–17. Delocrinus spp. 11a–c. D. matheri** (107), type. Post., dorsal, ant. **12. D. pictus** (108), type. Post. **13a–d. D. granulosus** (108), types. Dorsal, post., ant., ventral. **14a, b. D. missouriensis** (91), type. Post., dorsal. **15. D. somersi** (186), type. Dorsal. **16a, b. D. graphicus** (108), type. Post., dorsal. **17a, b. D. abruptus** (108), type. Post., dorsal. **18a–c. Graphiocrinus kingi** (108), type Ant., dorsal, post. **19a–c. Delocrinus vulgatus** (108), type. Post., dorsal, ventral. **20–25. Paradelocrinus spp. 20a–d. P. aequabilis** (107), type. Ant., post., dorsal, ventral. **21a–c. P. dubius** (107), type. Ant., dorsal, ventral. **22a–c. P. obovatus** (107), type. Dorsal, post., ventral. **23a–c. P. protensus** (108), type. Dorsal, ventral, post. **24a, b. P. planus** (178), type. Side, dorsal. **25. P. brachiatus** (108), type. Lat. **26. Delocrinus papulosus** (108), type. Dorsal. **27, 28. Erisocrinus spp. 27a, b. E. elevatus** (108), type. Dorsal, ant. **28a, b. E. typus** (108), type. Dorsal, post. **29. Delocrinus benthobatus** (108), type. Post. **30, 31. Ethelocrinus spp. 30a, b. E. sphaeralis** (91), type. Post., dorsal. **31a–c. E. texasensis** (108), type. Post., dorsal, ventral. **32a, b. Phanocrinus formosus** (64), type. Post., dorsal. **33a, b. Ethelocrinus magister** (91), type. Post., dorsal.

HOMALOCRINIDAE—Crown short IBB extending beyond stem Rays partly or wholly separated above RR



1

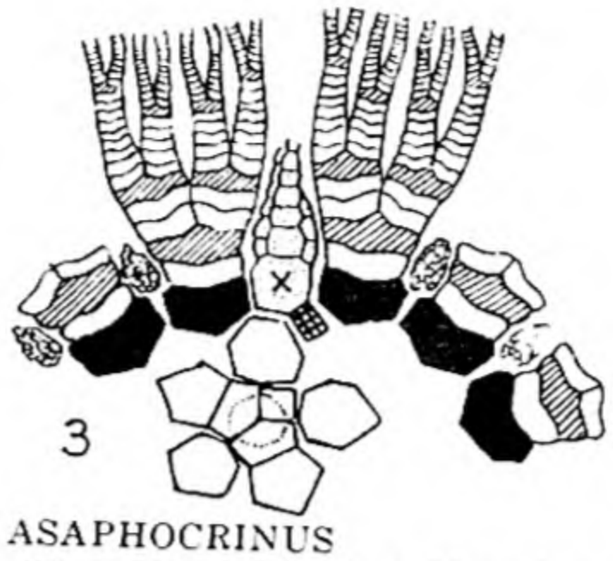
PYCNOSACCUS

RA present X alone, followed by perisome, PBrBr 1-4

2

HORMOCRINUS

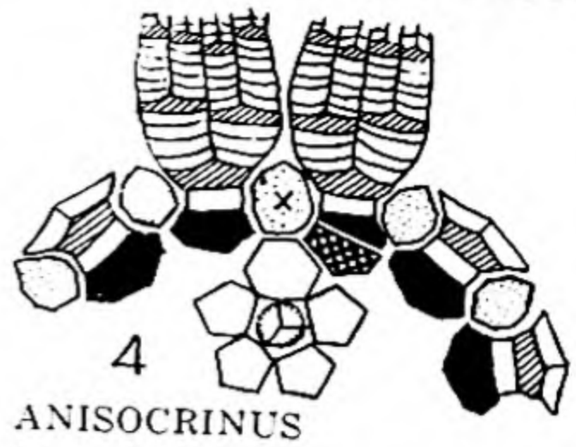
RA absent IBr followed by others abreast or by perisome



3

ASAPHOCRINUS

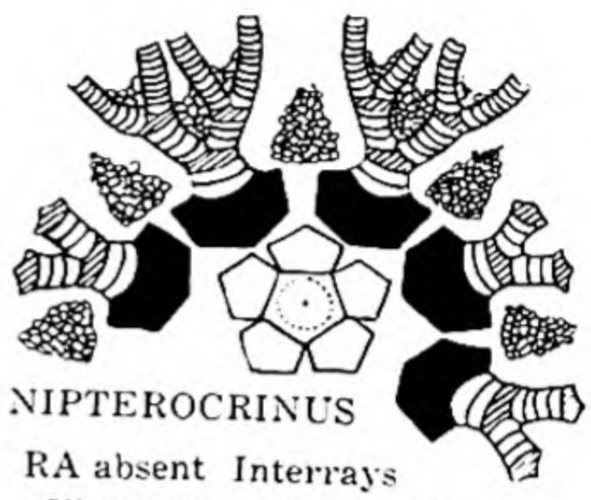
RA present X followed by others passing into tube, PBrBr 2



4

ANISOCRINUS

RA present IBr 1 in each interray

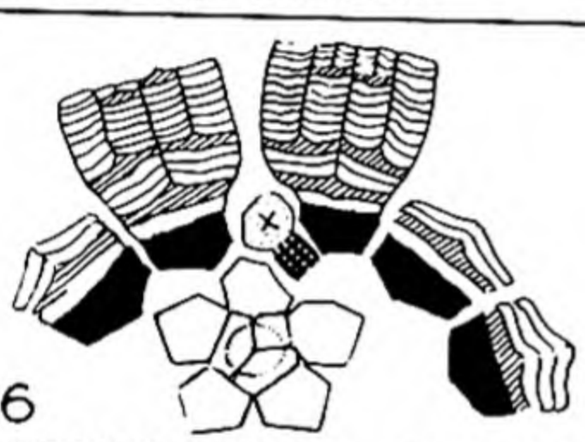


5

NIPTEROCRINUS

RA absent Interrays filled with perisome, X absent

LECANOCRINIDAE—Crown rotund IBB extending beyond stem Rays in contact except at anal side



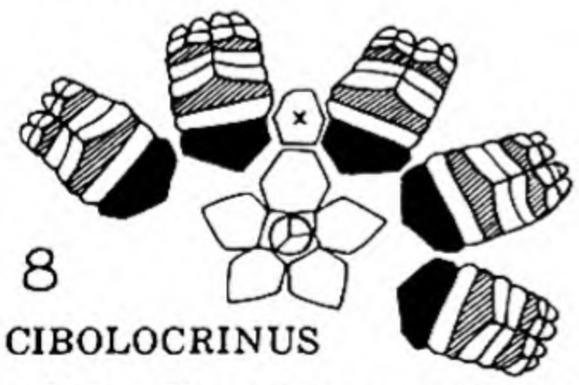
6

LECANOCRINUS RA present

7

MESPILOCRINUS

RA absent, X reaching only slightly below summit of RR, arms turned toward right.



8

CIBOLOCRINUS

RA absent, X reaching considerably below summit of RR, arms not turned

ICHTHYOCRINIDAE—IBB horizontal, covered by stem; crown elongate or rotund; rays widening up ward from RR, in close contact

9

CLIDOCHIRUS

Rays in contact except at anal side

RA directly or obliquely below RPR

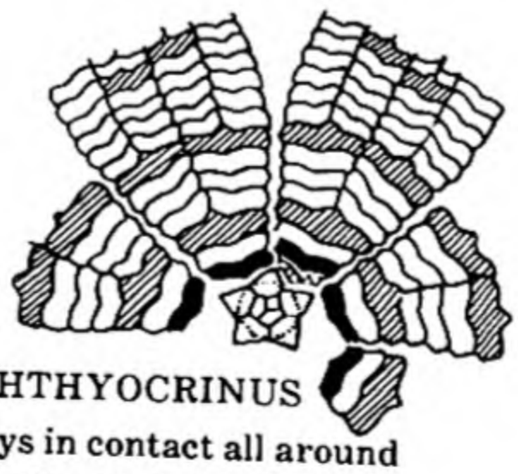
X resting on truncate PB, IBB unstable, extending beyond stem in some.

10

SYNAPTOCRINUS

Rays in contact all around

RA absent, PB elongate



11

ICHTHYOCRINUS

Rays in contact all around

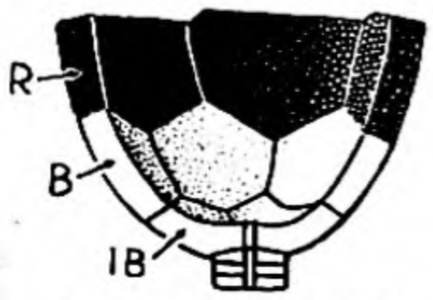
RA directly below RPR

12

METICHTHYOCRINUS

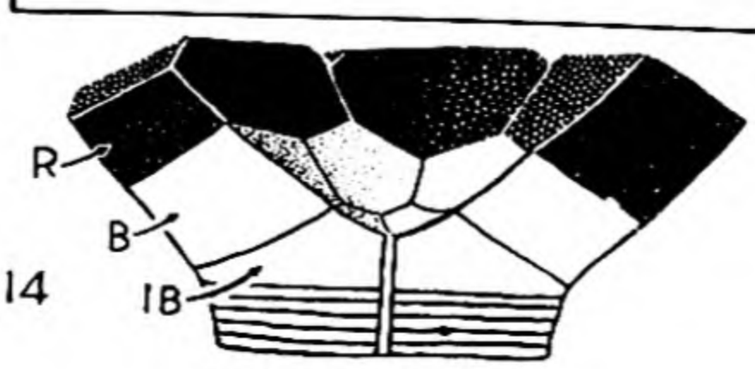
Rays in contact all around

RA absent, PB not differentiated



13

LECANOCRINUS



14

FORBESIOCRINUS

15

ICHTHYOCRINUS

STUARTWELLERCRINUS

Moore and Plummer 1938

(**Cibolocrinus turbinatus* Weller). Cup conical; three IBB; R facets wide, moderately long, bearing large muscle- and ligament-areas; RA and RX absent, X in line with RR or only indenting inner margin of facets of post. RR; arms unknown; stem round (108). **Perm.**

S. symmetricus (Weller) [**60**—19] (108). **Cibolo:** Tex.

Other genus: *?Missouricrinus* S. A. Miller 1891 (88).

CROMYOCRINIDAE. Dicyclic; cup globose; IBB five, visible from side; R facets wide and long, horizontal, bearing transverse ridge and muscle- and ligament-areas; two or three XX in cup. **Miss.–Perm.**

ULOCRINUS Miller and Gurley 1890

(**U. buttsi*). IBB flaring upward distinctly; RA and X in cup; arms branching isotomously on PBr_1 in all rays, biserial; stem round (91). **Penn., Perm.**

***U. buttsi** M and G [**56**—27]. Cup elongate bowl-shaped; RA not touching RPB, supporting X (91). **Penn.:** Mo. (Missouri).

U. sangamonensis (Meek and Worthen) [**56**—28]. Cup relatively wider than *U. buttsi*; RA quadrate, touching RPB, X large (82). **Penn.:** Ill. (Missouri).

U. kansasensis Miller and Gurley [**56**—26]. Cup wider than high; RA large, X very small; surface granulose (91). **Penn.:** Mo. (Missouri).

Other genus: *Cromyocrinus* Trautschold 1867.

EUPACHYCRINIDAE. Dicyclic; crown ovoid, cup globose, base flat or concave; IBB five, not visible from side; R facets as in Cromyocrinidae; two or three XX in cup; arms biserial, branching on PBr_1 and in some genera dividing on a SBr; stem round. **Miss., Penn.**

EUPACHYCRINUS Meek and Worthen 1865

(**Graphiocrinus quatuordecimbrachialis* Lyon). Base of cup deeply concave; IBB small, flaring downward; three XX in cup; rami 12 or more (64). **Miss.** (Chester).

***E. 14-brachialis** (Lyon) [**64**—33]. Rami three to each ray except anterior, which has two (64). **Chester:** Ky., Ill.

E. asperatus Worthen [**64**—34]. Angular nodes on BB, RR, RA and PBrBr (153). **Chester:** Ill.

E. spartarius S. A. Miller [**64**—28]. Like *E. 14-brachialis* but plates less tumid (64, 153). **Chester:** Ky.

ETHELOCRINUS Kirk 1937

(**Eupachycrinus magister* Miller and Gurley). Like *Eupachycrinus* but only two XX in cup; rami 16 to 18 (64). **Penn.**

E. oklahomensis Moore and Plummer. Prominent tubercles on plates (107). **Brentwood:** Ark., Okla.

E. texasensis Moore and Plummer [**65**—31]. Cup like *E. oklahomensis* but larger and wider (108). **Marble Falls:** Tex.

***E. magister** (M and G) [**65**—33]. Cup broad, low; surface marked by coarse irregular ridges and nodes (91). **Lane:** Mo.

E. sphaeralis (Miller and Gurley) [**65**—30]. Like *E. magister* but more globose (91). **Lane:** Mo., Okla.

PARULOCRINUS Moore and Plummer 1940

(**Ulocrinus blairi* Miller and Gurley). Like *Ethelocrinus* but IBB horizontal, basal concavity very shallow or lacking; arms branch isotomously on PBr_1 making total of 10 rami (108). **Penn.**

***P. blairi** (M and G) [**64**—37]. Cup large, base flat; surface smooth (108). **Missouri:** Mo.

P. compactus Moore and Plummer [**64**—36]. Sutures impressed, plates finely granulose (108). **Penn.:** Kan. (Winterset, Iola), Okla. (Ochelata), Tex. (Brad).

P. pustulosus Moore and Plummer [**64**—31]. Borders of plates marked by a row of low tubercles (108). **Mineral Wells:** Tex.

SELLARDSICRINUS Moore and Plummer 1940

(**S. marrsae*). Like *Parulocrinus* but arms branching three times, making eight rami to the ray at summit of crown (108). **Penn.** (Des Moines).

***S. marrsae** M and P [**64**—29] (108). **Millsap Lake:** Tex.

Other genera: *?Ageneracrinus* Sutton and Winkler 1940, *Cryphiocrinus* Kirk 1929 (56).

AGASSIZOCRINIDAE. Dicyclic; crown ovoid, cup bowl-shaped; IBB five or fused to a single thick plate, visible from side; R facets wide but short; one to four XX in cup; arms uniserial, branching isotomously once; stem typically absent in adult stages. **Miss., Penn., ?Perm.**

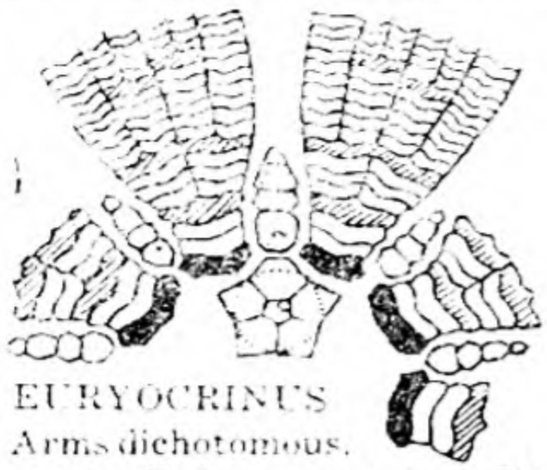
AGASSIZOCRINUS Owen and Shumard 1852

(**A. conicus*). IBB fused, stemless in adult stage; three or four XX in cup; arms branch on PBr_1 (140). **Miss.** (Chester).

PLATE 66

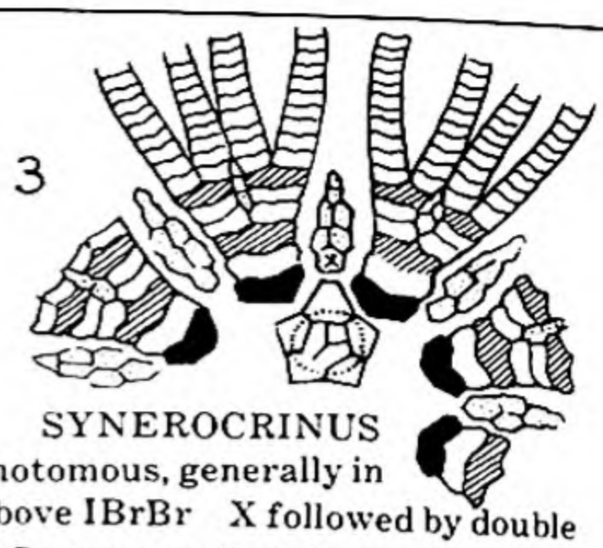
Analyses of flexible crinoids belonging to the families HOMALOCRINIDAE, LECANOCRINIDAE, and ICHTHYOCRINIDAE (RR black, IBrBr stippled, RA dark cross-ruled, AxAx oblique-ruled). Cross sections of lower part of dorsal cup of *Lecanocrinus* (13), *Forbesiocrinus* (14), and *Ichthyocrinus* (15) showing progressive construction of lowest circlets to area occupied by stem impression (modified from Springer).

SYNEROCRINIDAE—Like Ichthyocrinidae but rays partly separated above RR by IBrBr



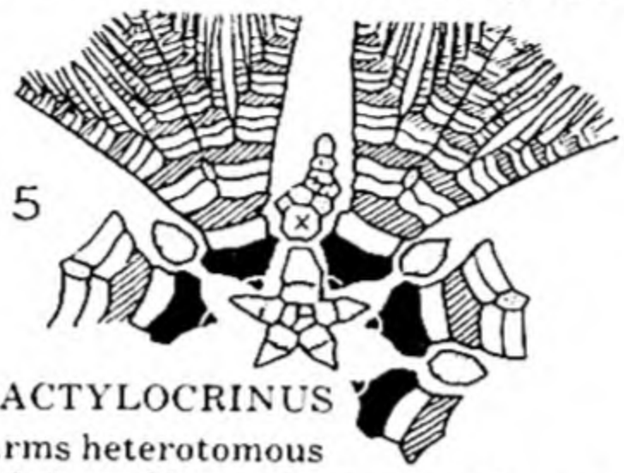
EURYOCRINUS
Arms dichotomous, generally in contact above IBrBr X followed by single series, IBrBr few, PBrBr 3, rays interlocking

AMPHICRINUS
Arms dichotomous, generally in contact above IBrBr X followed by single series, IBrBr numerous, PBrBr 2, rays interlocking

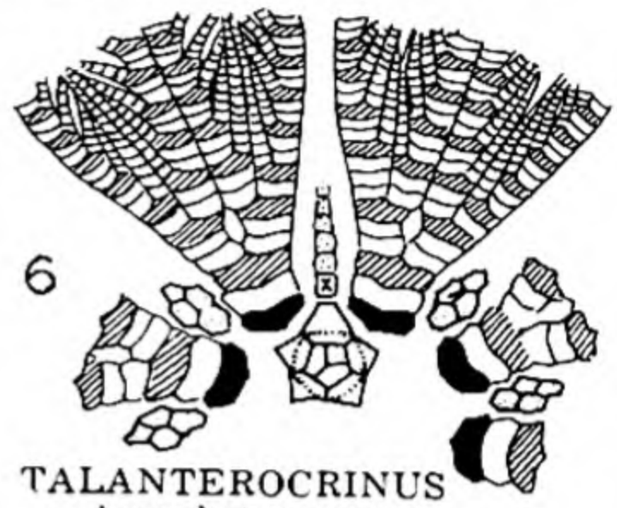


SYNEROCRINUS
Arms dichotomous, generally in contact above IBrBr X followed by double series, IBrBr intermediate in numbers, PBrBr 2, rays not interlocking

WACHSMUTHICRINUS
Arms heterotomous
X absent, PB not differentiated



DACTYLOCRINUS
Arms heterotomous
X followed by anals in more than one series

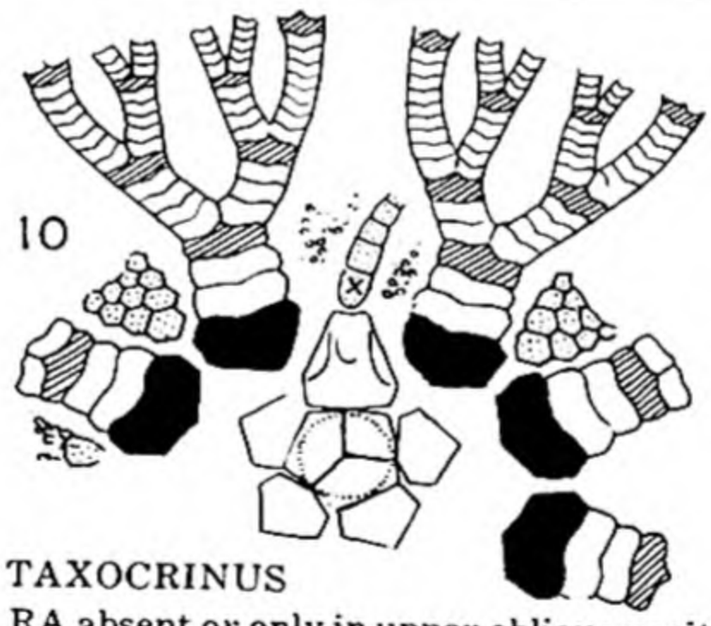


TALANTEROCRINUS
Arms heterotomous
X followed by single series

SAGENOCRINITIDAE-IBB recumbent, taking little part in calyx wall; crown typically elongate; rays partly or wholly separated above RR

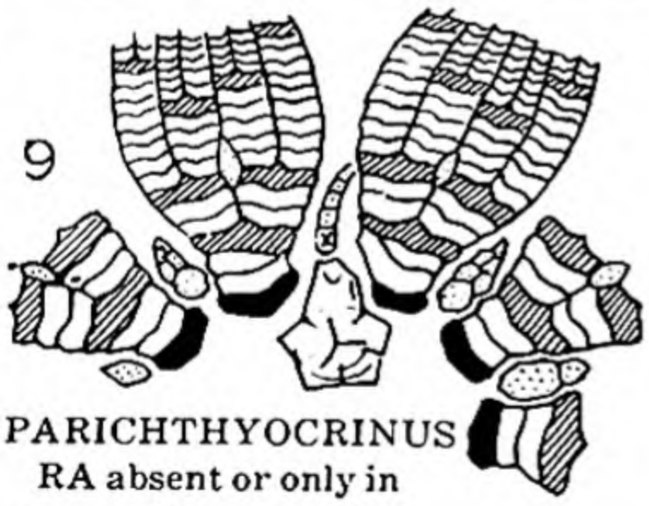
SAGENOCRINITES
RA low touching RPB, PBrBr 2

FORBESIOCRINUS
RA high not touching RPB, PBrBr typically 3



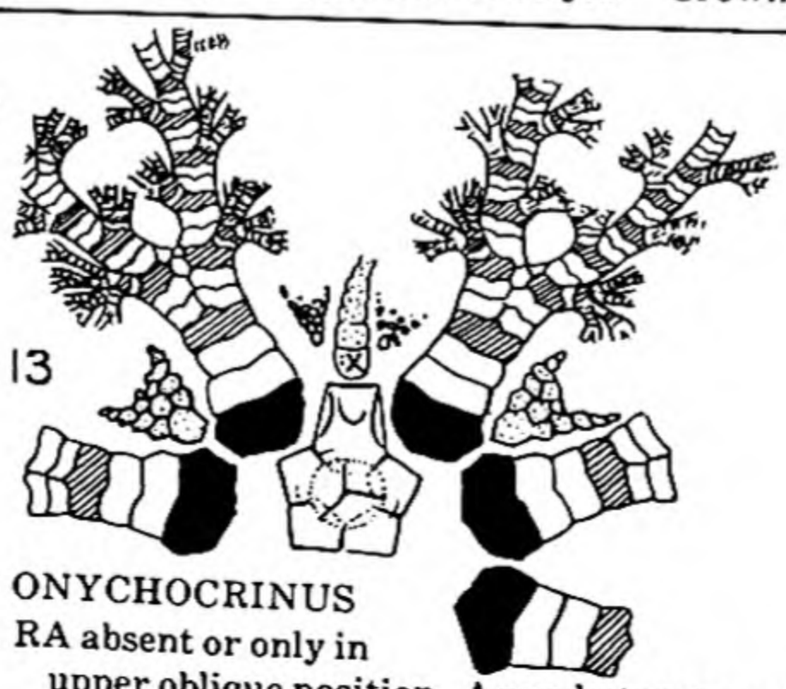
TAXOCRINUS
RA absent or only in upper oblique position
Arms dichotomous
IBrBr commonly numerous, PBrBr 3

TAXOCRINIDAE—Calyx weak, anal series tubelike, not suturally incorporated in calyx. Crown elongate

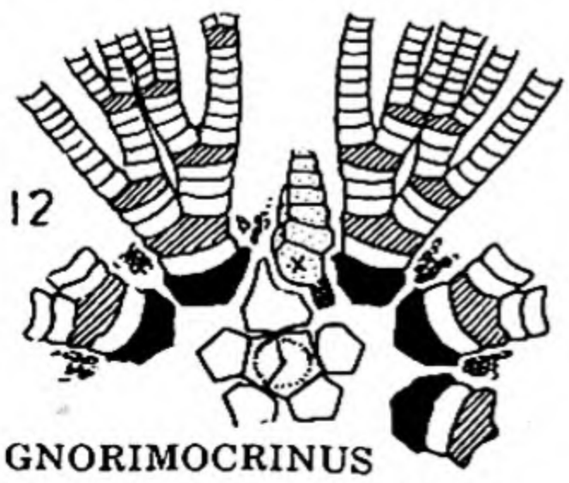


PARICHTHYOCRINUS
RA absent or only in upper oblique position
Arms dichotomous
IBrBr few, arms abutting above, PBrBr 3

PROTAXOCRINUS
RA in lower positions
RA in form of R, directly below RPR



ONYCHOCRINUS
RA absent or only in upper oblique position Arms heterotomous
10 main arm trunks, PBrBr 3 to 6



GNORIMOCRINUS
RA in lower positions
RA rhombic, obliquely below RPR

EUTAXOCRINUS
RA absent or only in upper oblique position Arms dichotomous
IBrBr variable, PBrBr 2

A. gibbosus Hall [**61**—5]. Distinguished by shape of cup; IB circlet one-third or less height of cup (140). **Chester:** Ill.

A. globosus Worthen [**61**—6]. Cup globose, IBB not solidly fused (140). **Gasper:** Ky.

A. laevis (Roemer) [**61**—8]. Cup elongate ovoid; IBB one-third or more of height of cup (140). **Chester:** Ky.

***A. conicus** O and S [**61**—7]. Cup unusually elongate conical; IBB one-half of height of cup (140). **Chester:** Ill.

A. ovalis Miller and Gurley [**61**—9]. Like *A. globosus* but IB circlet solidly fused (140). **Okaw:** Ill.

PARAGASSIZOCRINUS
Moore and Plummer 1940

(**Agassizocrinus tarri* Strimple). Like *Agassizocrinus* but only X in cup; arms branch on PBr_2 (108). **Penn.**

***P. tarri** (Strimple) [**56**—31] (108, 144). **Penn.:** Kan., Okla. (Stanton), Tex. (Graford).

ANARTIOCRINUS Kirk 1940

(**A. lyoni*). Like *Agassizocrinus* but IBB not fused, thin; stem present in adult; posterior rami of RAR and LAR enlarged (67). **Miss.** (Chester).

A. maxvillensis (Whitfield) [**61**—11] (67). **Glen Dean:** Ky.

Subclass Flexibilia

Dicyclic crinoids having lower BrBr incorporated in the dorsal cup, but not rigidly; IBB three, unequal; tegmen flexible, bearing exposed food grooves and mouth; arms uniserial, nonpinnulate; stem round. **Ord.–Perm.**

Order Taxocrinoidea. Flexible crinoids having an elongate crown and a weak calyx; X not joined by close suture to PB and PBrBr; XX formed into a tube that is separated by perisome from adjacent rays. **Ord.–Penn.**

TAXOCRINIDAE. Characters of the order.

PROTAXOCRINUS Springer 1906 [**67**—11]

(**Taxocrinus ovalis* Angelin). RA directly below RPR; IBB project beyond stem; PBrBr two, arms branch isotomously (131). **Ord.–Dev.**

P. elegans (Billings) [**68**—14]. IBB large and erect; BrBr angular, SBrBr five (131). **Ord.:** Canada (Trenton).

P. laevis (Billings) [**69**—7]. Like *P. elegans* but BrBr evenly rounded; SBrBr typically three or four (131). **Ord.:** Canada (Trenton).

P. robustus Springer [**54**—13]. IBB only slightly exposed beyond stem; arms massive, SBrBr three (131). **Sil.:** Tenn. (Beech River).

GNORIMOCRINUS
Wachsmuth and Springer 1879 [**67**—12]

(**Taxocrinus expansus* Angelin). Like *Protaxocrinus* but RA rhombic, obliquely below RPR (131). **Sil.** (Niagaran).

G. cirrifer Springer [**54**—12] (131). **Beech River:** Tenn.

EUTAXOCRINUS Springer 1906 [**67**—14]

(**Taxocrinus affinis* Müller). Like *Protaxocrinus* but RA in upper oblique position below RPR or absent; IBrBr variable (131). **Sil.–Miss.**

E. whiteavesi Springer [**68**—16]. Crown elongate, borders of BrBr raised; IBrBr absent; SBrBr typically three (131). **Dev.:** Canada (Hamilton).

E. ithacensis (Williams) [**69**—4]. Like *E. whiteavesi* but borders of BrBr not raised (131). **Dev.:** N. Y. (Portage).

E. fletcheri (Worthen) [**68**—10]. Crown short; SBrBr two or three, rami tapering rapidly (131). **Miss.:** Ia. (Hampton).

TAXOCRINUS Phillips 1843 [**67**—10]

(**Cyathocrinus? macrodactylus*). Like *Protaxocrinus* but RA obliquely below RPR or absent; PBrBr three and IBrBr commonly numerous (131). **Dev., Miss.**

T. telleri Springer [**68**—5]. Crown elongate, calyx narrow, base small; SBrBr five; IBrBr few, areas narrow (131). **Dev.:** Wis. (Hamilton).

T. intermedius Wachsmuth and Springer [**69**—1]. Crown short, spreading, calyx evenly rounded, large; SBrBr three; IBrBr well developed (131). **Miss.:** Ia. (Hampton).

T. ornatus Springer [**69**—9]. Crown elongate, calyx spreading; IBr areas wide, filled with perisome; arms marked by wrinkles (131). **Miss.:** Ia. (Burlington).

T. giddingsei (Hall) [**69**—13]. A small species; crown spreading, short; SBrBr three; IBr areas not touching BB (131). **Miss.:** Mo. (Keokuk).

T. colletti White [**69**—5]. Crown elongate, arms regularly tapering; SBrBr three or four; stem enlargement suddenly contracting (131). **Miss.:** Ind. (Keokuk).

T. whitfieldi (Hall) [**69**—6]. Like *T. giddingsei* but SBrBr two; IBrBr strong, in some specimens touching BB (131). **Miss.** (Chester): Ky., Ill.

T. huntsvillae Springer [**69**—16]. Like *T. giddingsei* but smaller and IBr areas touching BB (131). **Miss.:** Ala. (Chester).

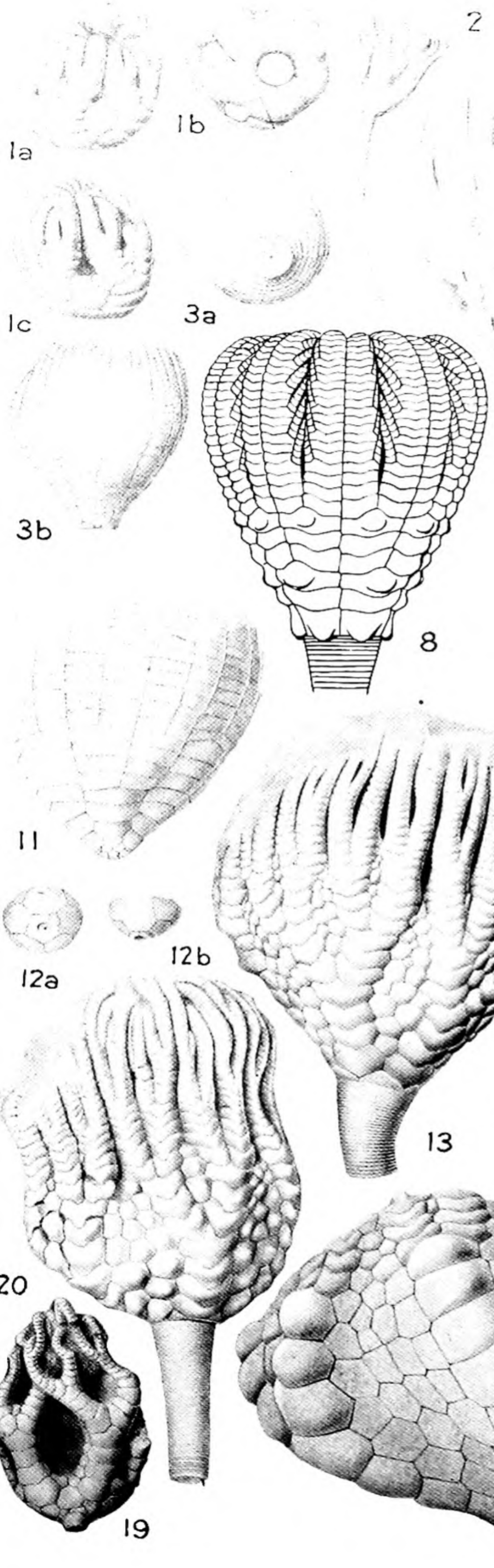
PARICHTHYOCRINUS Springer 1902 [**67**—9]

(**Ichthyocrinus nobilis* Wachsmuth and Springer). Like *Taxocrinus* but IBrBr few (131). **Miss.** (Osage).

***P. nobilis** (W and S) [**69**—8]. Rays not promi-

PLATE 67

Analyses of flexible crinoids belonging to the families SYNEROCRINIDAE, SAGENOCRINITIDAE, and TAXOCRINIDAE (RR black, IBrBr stippled, RA dark cross-ruled, AxAx oblique-ruled).


1a
1b
1c
2
3a
3b
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11
12a
12b
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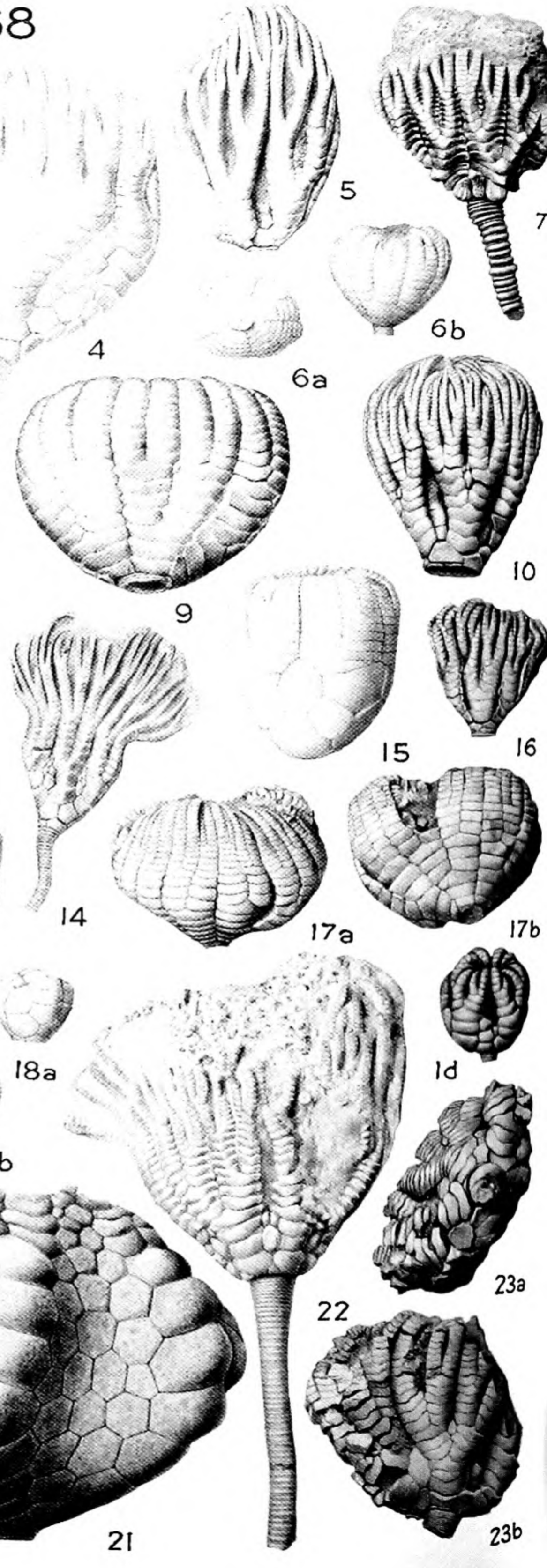
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6a
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17a
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18a
18b
1d
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23a
23b

nent, arms broad and flat; crown higher than wide (131). **Burlington:** Ia.

P. meeki (Hall) [**69**—12]. Rays prominent, arms rounded; crown wider than high (131). **Keokuk:** Ill., Ia.

ONYCHOCRINUS

Lyon and Casseday 1860 [**67**—13]

(**O. exsculptus*). Like *Taxocrinus* but arms heterotomous, having 10 main trunks; PBrBr three to six (131). **Miss., Penn.**

O. asteriaeformis (Hall) [**69**—10]. IBrBr numerous; ramules on one side only, outside of dichotom; PBrBr three (131). **Miss.:** Ia. (Burlington).

O. ulrichi Miller and Gurley [**69**—15]. Like *O. asteriaeformis* but ramules on both sides, PBrBr four, and rami longer; anal tube large (131). **Miss.:** Ind. (Keokuk).

***O. exsculptus** L and C [**69**—19]. Like *O. ulrichi* but rami slender and gradually tapering; ramules delicate, clusters numerous (131). **Miss.** (Keokuk): Ind., Ill., Ia.

O. pulaskiensis Miller and Gurley [**69**—3]. IBrBr few; ramules bilateral, alternating, rami strong, ramules not in clusters, PBrBr three (131). **Miss.** (Chester): Ky., Ala., Ill.

Order Sagenocrinoidea. Flexible crinoids having a strong calyx, X partly joined by close suture to PB and PBrBr, XX not formed into a tube, or XX absent. **Sil.–Perm.**

SAGENOCRINITIDAE. Crown elongate; IBB subhorizontal, may be covered by stem impression; rays partly or wholly separated above RR by broad areas of IBrBr. **Sil.–Miss.**

SAGENOCRINITES

T. Austin and T. Austin, Jr. 1842 [**67**—7]

(**Actinocrinites? expansus* Phillips). RA low, touching RPB; PBrBr two (131). **Sil.** (Niagaran).

S. clarki Springer [**54**—10]. Large ovoid crown (131). **Beech River:** Tenn.

S. americanus Springer [**54**—11]. Cup conical, much smaller than *S. clarki* (131). **Waldron:** Ind.

FORBESIOCRINUS

Koninck and LeHon 1854 [**66**—14, **67**—8]

(**F. nobilis*). RA high, not touching RPB; PBrBr typically three (131). **Miss.:** (Kinderhook, Osage).

F. communis Hall [**68**—19]. A small species having strongly differentiated rays (131). **Cuyahoga:** Ohio.

F. burlingtonensis Springer [**68**—20]. Crown elongate, cup rounded; plates somewhat nodose (131). **Burlington:** Ia.

F. pyriformis Miller and Gurley [**68**—13]. A large species distinguished by its pear-shaped outline (131). **Keokuk:** Ky., Tenn.

F. saffordi Hall [**68**—21]. Broad crown having depressed interradial areas (131). **Keokuk:** Tenn.

F. multibrachiatus Lyon and Casseday [**68**—4]. Crown evenly rounded; plates less convex than those of *F. pyriformis* (131). **Keokuk:** Ind.

SYNEROCRINIDAE. Crown elongate, rotund; IBB horizontal, covered by stem; rays widening upward from RR, partly separated by IBrBr, branches isotomous or heterotomous. **Dev.–Perm.**

EURYOCRINUS Phillips 1836 [**67**—1]

(**E. concavus*). Arms branch isotomously, rays interlocking above IBrBr, which are few, PBrBr three; X in line with RR followed by a single series (131). **Dev., Miss.**

E. barrisi Springer [**68**—22]. Calyx elongate; BrBr marked by median elevation; IBB covered by stem, but large; BB visible as triangles (131). **Dev.** (Hamilton): Mich., Ia.

E. tennesseensis Springer [**68**—23]. Calyx spreading broadly; BrBr gently convex; IBB very small; BB barely visible or covered by stem (131). **Miss.** (Osage): Ind. (New Providence), Ky., Tenn.

AMPHICRINUS Springer 1906 [**67**—2]

(**A. scoticus*). Like *Euryocrinus* but IBrBr numerous and PBrBr two (131). **Miss., Penn.**

A. carbonarius Springer [**79**—32]. A relatively large species; calyx broad (76, 131). **Penn.:** Kan. (Marmaton), Okla. (Oologah).

SYNEROCRINUS Jaekel 1898 [**67**—3]

(**Forbesiocrinus incurvus* Trautschold). Arms branch isotomously, generally in contact but not interlocking above IBrBr, which are intermediate in numbers; X followed by double row of plates; PBrBr two (108, 131). **Penn.** (Des Moines).

S. formosus Moore and Plummer [**56**—20]. Calyx ovoid (108). **Millsap Lake:** Tex.

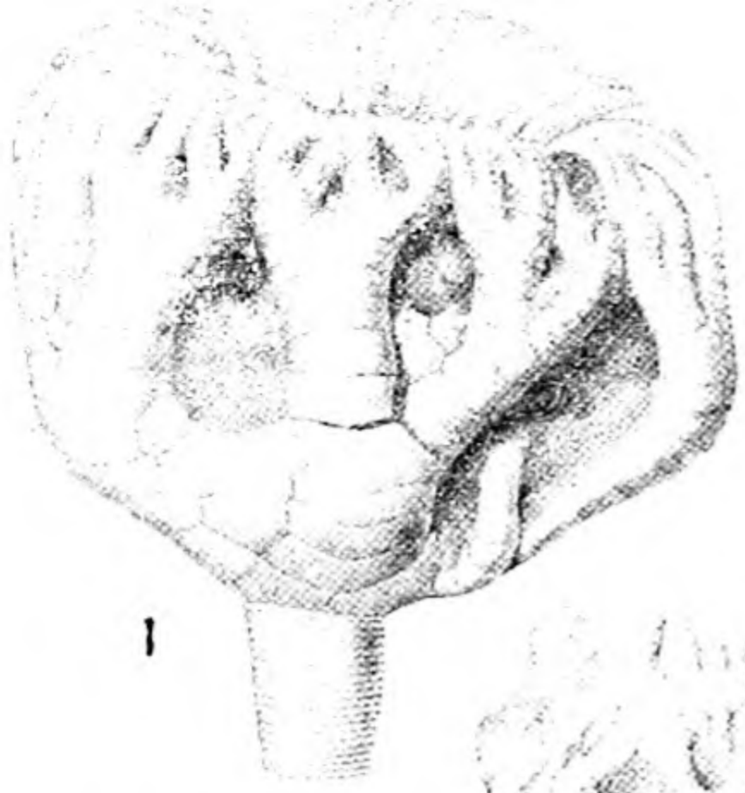
DACTYLOCRINUS Quenstedt 1876 [**67**—5]

(**Dimerocrinites oligoptilus* Pacht). Arms branch heterotomously bi-endotomously; X followed by plates in more than one series (131). **M. Dev., Miss.** (Kinderhook).

PLATE 68

[Figures are ×1 unless otherwise indicated; all figures after Springer (131).]

1a–d. Dactylocrinus concavus, types. Ant., dorsal, post., post. **2. Asaphocrinus ornatus.** Lat. **3a, b. Ichthyocrinus laevis.** Dorsal, right ant. **4. Forbesiocrinus multibrachiatus.** Post. **5. Taxocrinus telleri.** Post. **6a, b. Metichthyocrinus burlingtonensis.** Dorsal, lat. **7. Synaptocrinus nuntius.** Post. **8. Wachsmuthicrinus spinulosus.** Restoration of type. **9. Metichthyocrinus clarkensis.** Lat. **10. Eutaxocrinus fletcheri.** Post. **11. Ichthyocrinus corbis.** Right post. **12a, b. Mespilocrinus blairi.** Dorsal, post. **13. Forbesiocrinus pyriformis,** type. Ant. **14. Protaxocrinus elegans,** type. Ant. **15. Lecanocrinus macropetalus,** type. Post. **16. Eutaxocrinus whiteavesi,** type. **17a, b. Ichthyocrinus devonicus,** type. Post., ant. **18a, b. Mespilocrinus koninckі** (x2). Post., dorsal. **19–21. Forbesiocrinus** spp. **19. F. communis,** type. Post. **20. F. burlingtonensis.** Ant. **21. F. saffordi,** type. Right ant. **22, 23. Euryocrinus** spp. **22. E. barrisi.** Right ant. **23a, b. E. tennesseensis,** type. Dorsal, left post.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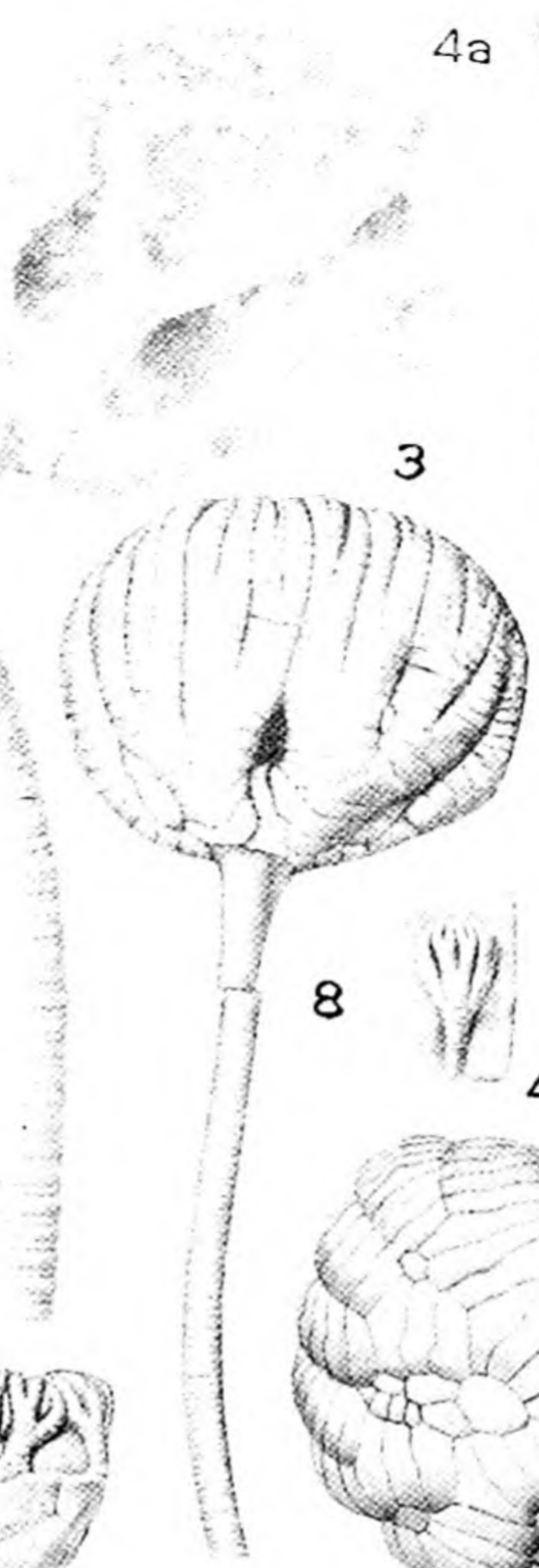
2b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4a

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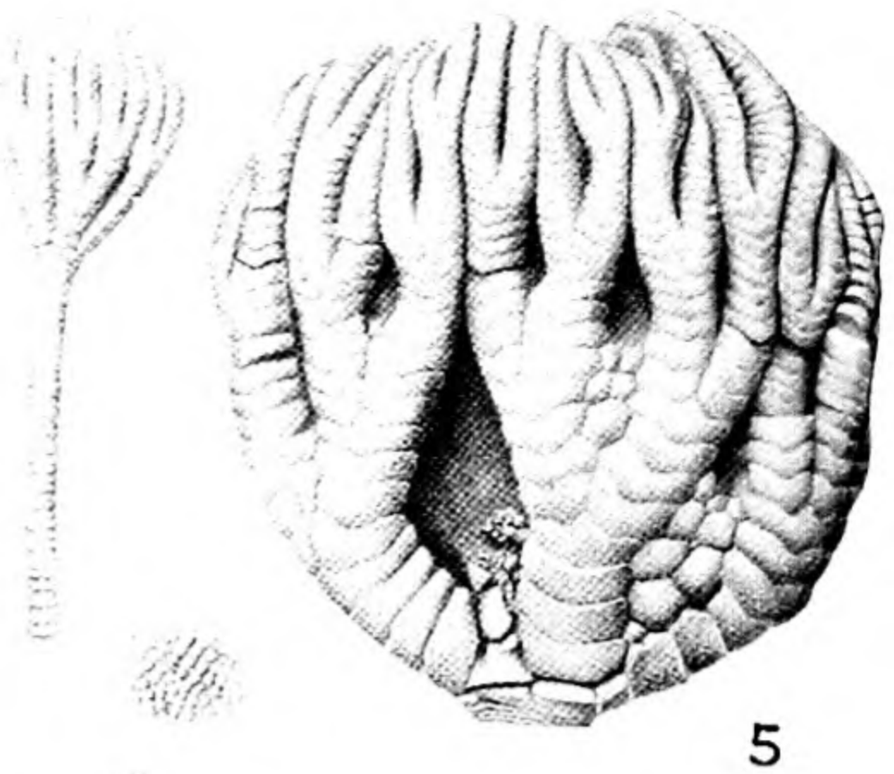
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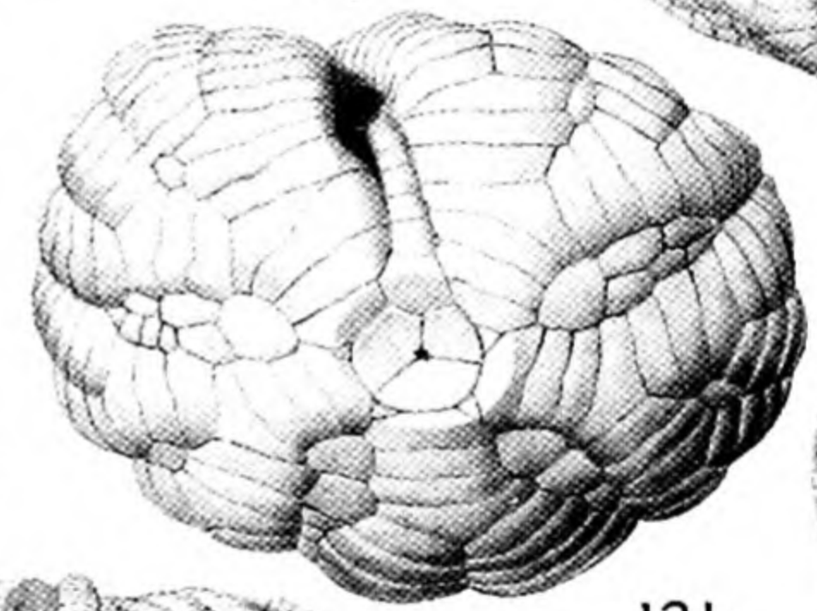
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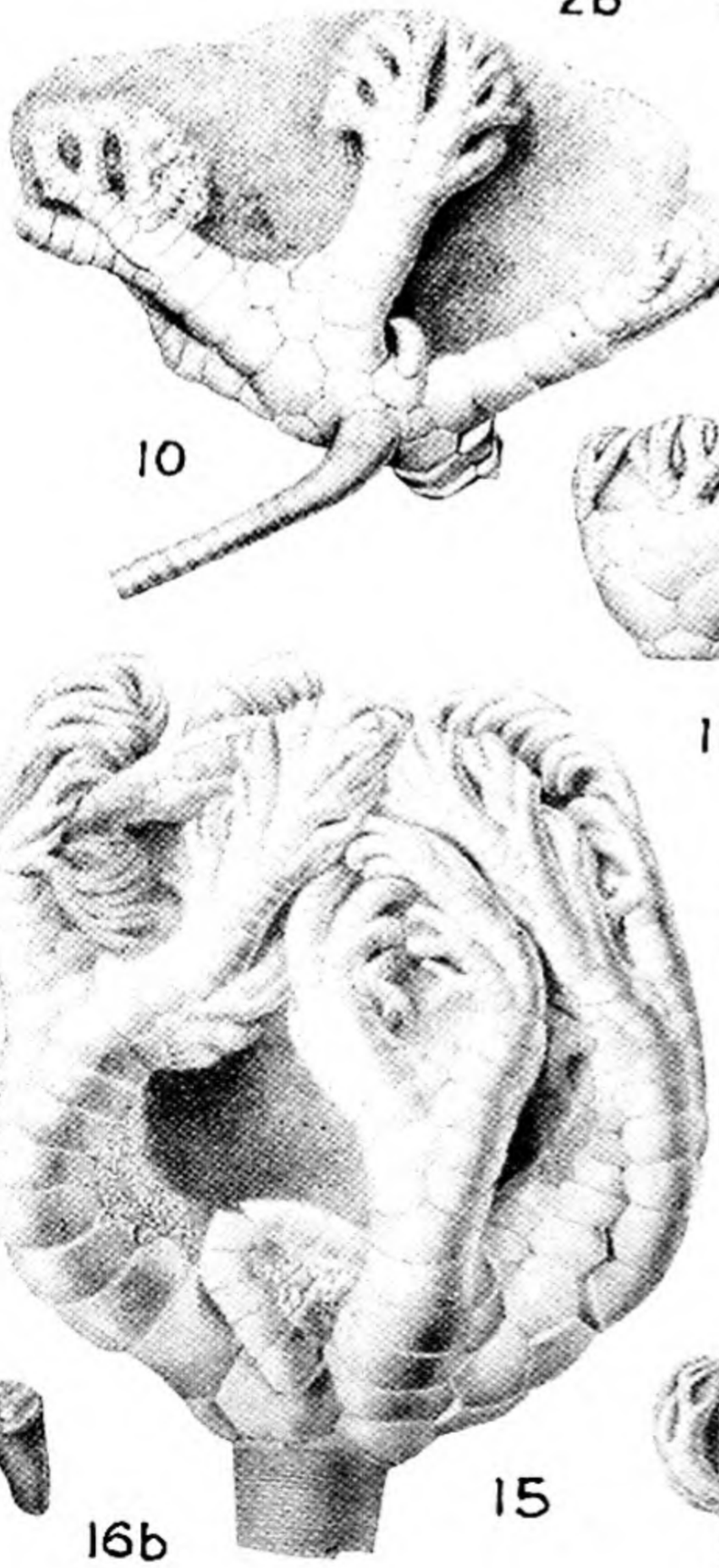
12a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16b

16a

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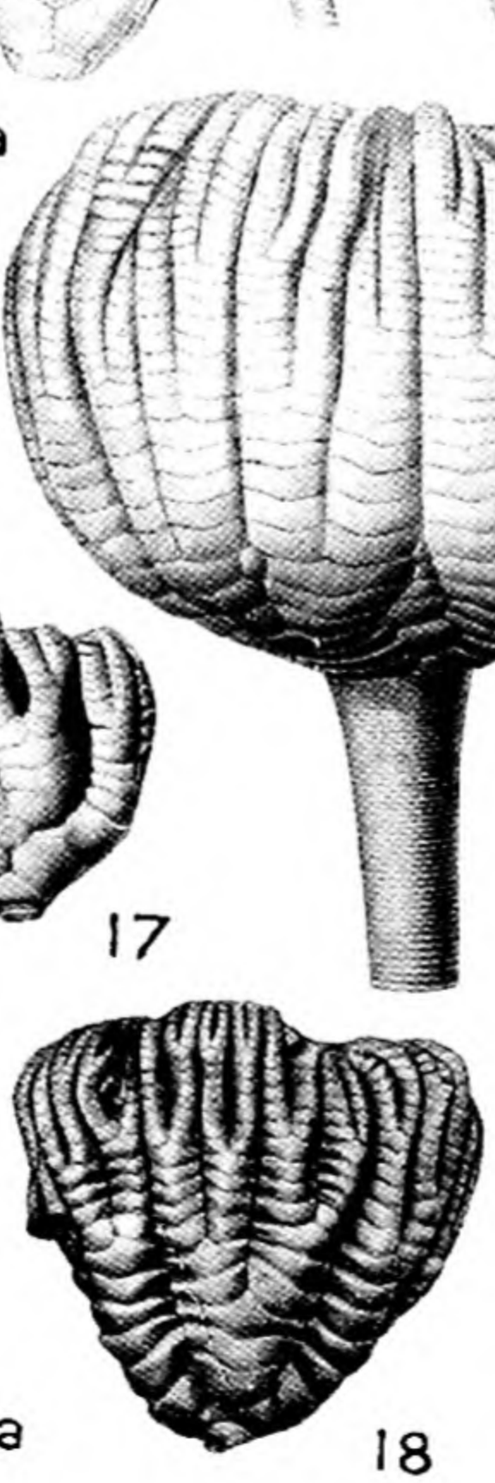
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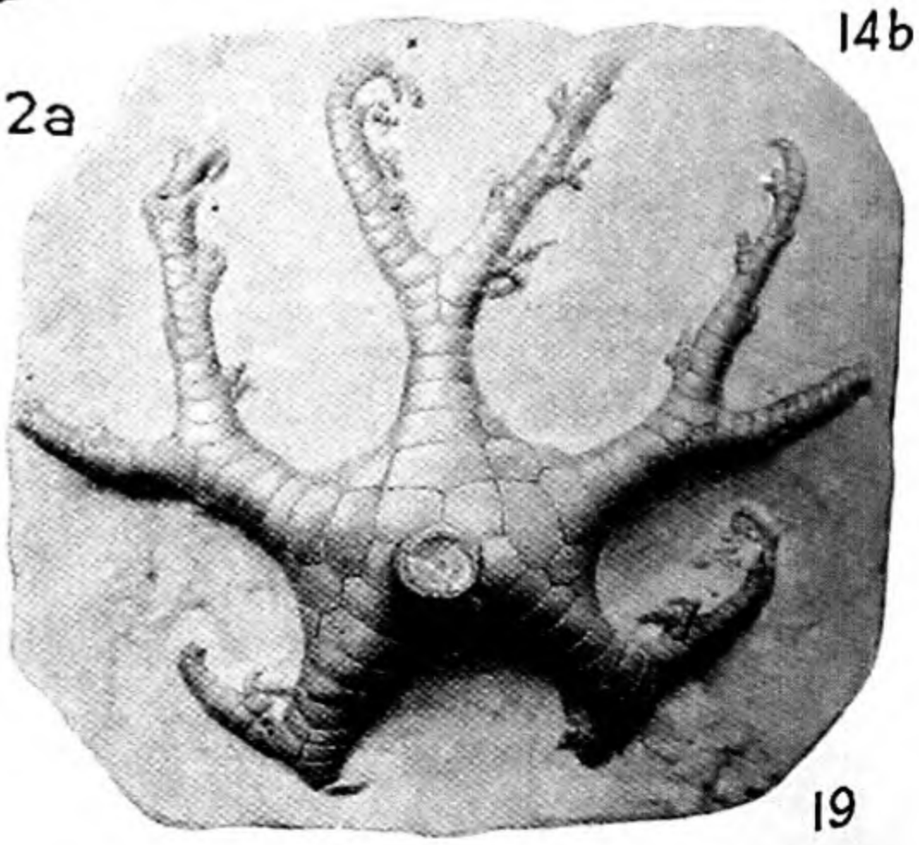

19

11a

11b

13

14a

14b

D. concavus (Rowley) [**68**—1]. Crown short, rotund; ramules small (131). **Dev.:** Mo. (Hamilton).

D. alpena Springer [**69**—14]. Crown elongate; ramules large, resembling main arm divisions (131). **Dev.:** Mich. (Hamilton).

WACHSMUTHICRINUS Springer 1902 [**67**—4] (**Forbesiocrinus thiemi* Hall). Like *Dactylocrinus* but X absent, PB not differentiated (131). **Miss.** (Osage).

W. spinulosus (Miller and Gurley) [**68**—8]. BB covered by stem; ramules small; IBrBr absent (131). **Miss.** (Borden): Ind., Ky. (Knobstone).

TALANTEROCRINUS
Moore and Plummer 1940 [**67**—6]

(**T. jaekeli*). Like *Dactylocrinus* but X followed by a single series of plates (108, 131). **Penn.** (Des Moines–Virgil).

T. mcguirei (Moore) [**56**—30]. A medium-sized species; plates smooth (103). **Brownville:** Okla.

HOMALOCRINIDAE. Crown short, rotund; IBB extending beyond stem impression; rays partly separated by IBrBr. **Sil., Dev.**

PYCNOSACCUS Angelin 1878 [**66**—1]

(**Cyathocrinites? scrobiculatus* Hisinger). RA present, X in line of RR, followed by perisome; R facets narrow; PBrBr one to four, arms branching isotomously (131). **Sil., Dev.**

P. patei Springer [**54**—4]. Plates of cup angulated (131). **Sil.:** Tenn. (Beech River).

P. tenuibrachiatus Springer [**69**—11]. Plates of cup not angulated; arms slender (131). **Sil.:** W. Va, (Keyser).

ANISOCRINUS Angelin 1878 [**66**—4]

(**A. interradiatus*). Like *Pycnosaccus* but one IBr in each interray; RA may be in primitive position directly below RPR (131). **Sil.** (Niagaran).

A. greenei (Miller and Gurley) [**54**—8]. A large species; RA not touching RAR (131). **Niagaran:** Ky., Tenn. (Louisville).

A. oswegoensis (Miller and Gurley) [**54**—7]. A small species; RA touching RAR (131). **Niagaran:** Ill.

ASAPHOCRINUS Springer 1920 [**66**—3]

(**A. bassleri*). Like *Pycnosaccus* but X followed by a vertical series of plates; PBrBr two (131). **Sil.** (Niagaran).

***A. bassleri** Springer [**54**—9]. A large species (131, 142). **Beech River:** Tenn.

A. ornatus (Hall) [**68**—2, **69**—17]. Smaller than *A. bassleri*, branches more slender and fewer (131, 142). **Rochester:** N. Y.

HORMOCRINUS Springer 1920 [**66**—2]

(**Centrocrinus tennesseensis* Worthen). Like *Pycnosaccus* but RA absent; IBr_1 followed by others or by perisome (131). **Sil.** (Niagaran).

***H. tennesseensis** (Worthen) [**54**—6]. Only described American species (131, 142). **Niagaran:** Ind. (Laurel), Tenn. (Brownsport).

NIPTEROCRINUS Wachsmuth 1868 [**66**—5]

(**N. wachsmuthi* Meek and Worthen). Like *Pycnosaccus* but RA and X absent; IBB fused (131). **Miss.** (Osage).

***N. wachsmuthi** M and W [**69**—2] (131). **Burlington:** Ia.

LECANOCRINIDAE. Crown short, rotund; IBB extending beyond stem; rays in contact except at anal side, arms incurving at tips. **Sil.–Perm.**

LECANOCRINUS Hall 1852 [**66**—6, 13]

(**L. macropetalus*). RA present (131, 142). **Sil., Dev.**

L. pusillus Hall [**54**—1]. A small species; BB and RA large (131). **Sil.** (Waldron): Ind., Tenn.

L. pisiformis (Roemer) [**54**—2]. Like *L. pusillus* but plates thinner, and BB and RA proportionally smaller (131). **Niagaran:** Tenn.

***L. macropetalus** Hall [**68**—15]. Crown relatively large, taller than wide (131). **Sil.** (Rochester): Canada; N. Y.

MESPILOCRINUS
Koninck and LeHon 1854 [**66**—7]

(**M. forbesianus*). Like *Lecanocrinus* but RA absent and X reaching only slightly below summit of RR; arms turned toward right (131). **Miss.** (Osage).

M. konincki Hall [**68**—18]. Crown small, biturbinate (131). **Burlington:** Ia.

M. blairi (Miller and Gurley) [**68**—12]. Like *M. konincki* but crown globose, IBB more protuberant, and stem facet smaller (131). **Sedalia:** Mo.

CIBOLOCRINUS Weller 1909 [**66**—8]

(**C. typus*). Like *Mespilocrinus* but commonly much larger, X reaching well below summit of RR and arms not twisted (107, 108). **Penn., Perm.**

***C. typus** Weller [**56**—16]. Cup broad bowl-

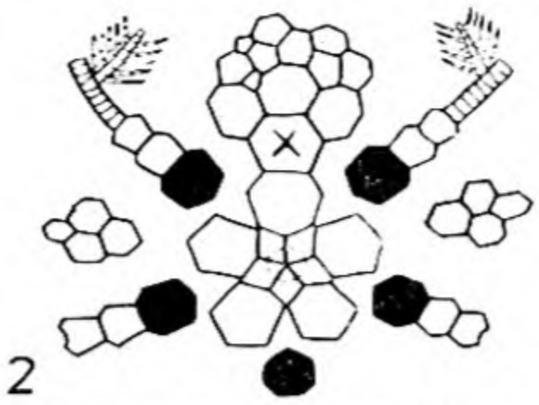
PLATE 69

[Figures are x1 unless otherwise indicated; all figures after Springer (131).]

1. Taxocrinus intermedius. Left post. **2a, b. Nipterocrinus wachsmuthi.** Opposite sides of a specimen. **3. Onychocrinus pulaskiensis.** Post. **4a, b. Eutaxocrinus ithacensis.** Ant. (type); a younger specimen. **5, 6. Taxocrinus** spp. **5. T. colletti.** Post. **6a, b. T. whitfieldi.** Dorsal, right ant. **7. Protaxocrinus laevis.** Ant. **8. Parichthyocrinus nobilis.** Post. **9. Taxocrinus ornatus,** type. Ant. **10. Onychocrinus asteriaeformis.** Post. **11a, b. Pycnosaccus tenuibrachiatus.** Left ant., right post. **12a, b. Parichthyocrinus meeki.** Ant., dorsal. **13. Taxocrinus giddingsi.** Post. **14a, b. Dactylocrinus alpena.** Ant., post. **15. Onychocrinus ulrichi.** Post. **16a, b. Taxocrinus huntsvillae.** Post., stem with attached IBB. **17. Asaphocrinus ornatus,** type. Post. **18. Clidochirus keyserensis.** Ant. **19. Onychocrinus exsculptus.** Dorsal.

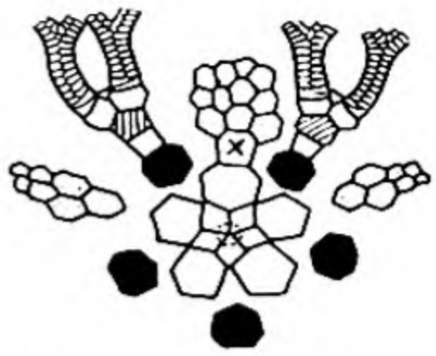
1

RETEOCRINUS—Dicyclic. IRR poorly defined. Ray plates separated by irregular pieces.



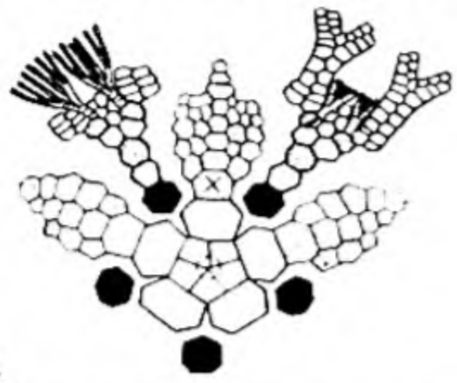
2

LAMPTEROCRINUS. Calyx asymmetrical. Anal side bulging. IBrBr few. Column pentagonal.



3

EUDIMEROCRINUS—Dicyclic. RR in contact except at posterior side. Arms branching many times.



4

GILBERTSOCRINUS—Dicyclic. Ventral disk usually wider than dorsal cup. Tubular appendages and small dwarfed arms.

5

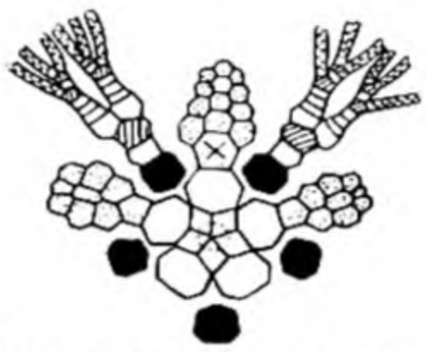
GAZACRINUS—Dicyclic. Base concave. IBB small, confined to basal concavity. X resting on truncate PB. Single IBr in calyx.

6

ARCHAEOCRINUS—Dicyclic. X resting on truncate PB. Arms branching. Anus without tube. Calyx obovate, large.

7

CLARKEOCRINUS—Monocyclic. BB 3. No anal plates. Arms four to each ray. IBrBr less numerous than in Dolatocrinus. Long cirri.



8

RHODOCRINITES—Dicyclic. Calyx globose. Flattened or concave base. No ISBrBr. Extra plates in anal series.

9

PTYCHOCRINUS—Dicyclic. Anus without tube. Calyx deep. Arms 10, uniserial.

10

GLYPTOCRINUS—Monocyclic. BB 5. PBrBr two. PBr_1 hexagonal. Anal interradius well developed. Arms uniserial, simple.

11

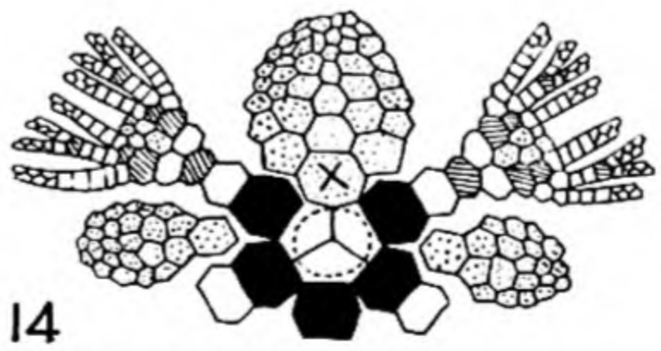
ALLOCRINUS—Monocyclic. No anal plates. BB 3. PBrBr two. PBr_1 quadrangular. Arms uniserial.

12

CTENOCRINUS—Monocyclic. BB 4. PBrBr two. PBr_1 hexagonal. Arms extended into 5 tubular trunks.

13

THAMNOCRINUS—Monocyclic. BB 3. Arms endotomous, branching at least four times, biserial.



14

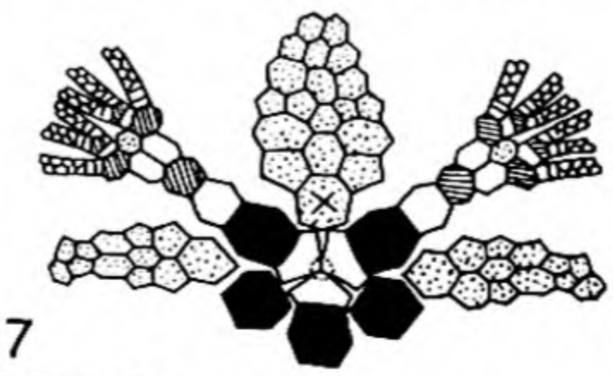
GENNAEOCRINUS—Monocyclic. BB 3. RR five plus X. Anal area wide. Calyx low, flaring. Arms grouped.

15

MACROSTYLOCRINUS—Monocyclic. BB 3. RR in contact all around. PBrBr 2. Arms 10, biserial, simple. Anal area well defined.

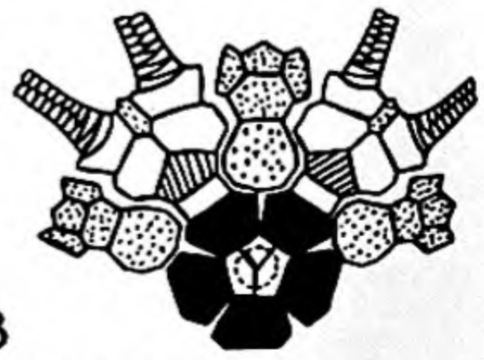
16

DOLATOCRINUS—Monocyclic. BB 3. No anal plates. PBrBr two. PBr_1 quadrangular. Calyx depressed subglobose. IBr_1 large.



17

PERIECHOCRINITES—Monocyclic. BB 3. Like Saccocrinus except having 30-40 arms.



18

STEREOCRINUS—Like Dolatocrinus except that it carries only one PBr.

shaped; plates smooth (108, 174). **Perm.:** Tex. (Cibolo).

C. banioni Moore [56—29]. Cup larger and proportionately wider than *C. typus*; plates decorated by radiating rows of nodes (103). **Penn.:** Okla. (Brownville).

C. punctatus Moore and Plummer [56—13]. Smaller than *C. typus*; base of cup flat, sides steep; surface granulose (108). **Penn.:** Tex. (Marble Falls).

C. tumidus Moore and Plummer [56—15]. Like *C. punctatus* but plates bulging (107). **Penn.:** Okla. (Brentwood).

ICHTHYOCRINIDAE. Crown elongate or rotund; IBB horizontal, covered by stem; rays widening upward from RR, in close contact. **Sil.–Miss.**

CLIDOCHIRUS Angelin 1878 [66—9]

(**C. pyrum*). Rays in contact except at posterior side; IBB extend beyond stem or entirely covered by stem; RA directly or obliquely below RPR, X on PB, in line with RR (131). **Sil., Dev.**

C. americanus Springer [54—3]. Crown small, elongate (131, 142). **Sil.:** Ohio (Clinton).

C. keyserensis Springer [69—18]. Crown relatively large; BrBr somewhat keeled (131). **Sil.:** W. Va. (Keyser).

ICHTHYOCRINUS Conrad 1842 [66—11, 15]

(**I. laevis*). Rays in contact all around; RA directly below RPR, no X (131). **Sil., Dev.**

***I. laevis** Conrad [68—3]. Calyx rounded, having low radial ridges; BB small, visible as triangles at edge of stem; SBrBr four (131). **Sil.** (Rochester): Canada; N. Y.

I. subangularis Hall [54—5]. Calyx angular, base contracted to a neck; BB large, visible as pentagons; SBrBr 4 (131). **Sil.:** N. Y. (Rochester), Ind. (Waldron), Ill. (Racine).

I. corbis Winchell and Marcy [68—11]. Crown ovoid, obscure radial ridges; BB covered by stem; SBrBr four (131). **Sil.:** Ill. (Racine).

I. devonicus Springer [68—17]. Crown pyriform, no radial ridges; BB covered by stem; SBrBr three (131). **Dev.:** Tenn. (Linden).

SYNAPTOCRINUS Springer 1920 [66—10]

(**Forbesiocrinus nuntius* Hall). Rays in contact all around; RA and X absent; PB elongate, reaching above RR (131). **M. Dev.**

***S. nuntius** (Hall) [68—7] (131). **Hamilton:** N. Y.

METICHTHYOCRINUS Springer 1906 [66—12]

(**Ichthyocrinus tiaraeformis* Hall). Rays in contact all around; RA and X absent; PB not differentiated (131). **Miss.** (Osage).

M. burlingtonensis (Hall) [68—6]. A small species (131). **Burlington:** Ia., Mo.

M. clarkensis (Miller and Gurley) [68—9]. A large species (131). **New Providence:** Ind., Ky., Tenn.

Subclass Camerata

Crinoids in which the lower BrBr and IBrBr take part in the dorsal cup, all plates united by rigid suture; arms pinnulate; mouth and food grooves closed. **Ord.–Perm.**

Order Diplobathra. Dicyclic camerate crinoids. **Ord.–Perm.**

RETEOCRINIDAE. Dicyclic; RR separated all around; rays marked by conspicuous median ridge; IBr areas depressed, irregular, composed of numerous small plates; anal area depressed, divided by a vertical series of larger plates forming a median ridge. **Ord.**

RETEOCRINUS Billings 1859 [70—1]

(**R. stellaris*). Cup conical; IBB five, small, barely projecting beyond column; RR five, separated all around; PBrBr two, SBrBr 10 to 14, lower ones united in dorsal cup, upper in free arms, which are uniserial and branch isotomously; column pentagonal (163). **Ord.** (Mohawkian, Cincinnatian).

R. nealli (Hall) [72—1, 8] (163). **Richmond:** Ohio.

ARCHAEOCRINIDAE. Dicyclic; RR separated all around; IBrBr regularly polygonal; median ray ridge present in more primitive genera; anal side with extra plates; median anal ridge not present; cup high. **Ord.–Dev.**

RHAPHANOCRINUS

Wachsmuth and Springer 1885

(**Glyptocrinus subnodosus* Walcott). Median ray ridges on rays; IBr areas depressed; plates stellate (163). A primitive archaeocrinid probably derived from *Reteocrinus*. **Ord.** (Chazyan–Richmond).

R. sculptus (S. A. Miller) [72—23] (163). **Richmond:** Ohio.

ARCHAEOCRINUS

Wachsmuth and Springer 1881 [70—6]

(**Glyptocrinus lacunosus* Billings). Calyx large, thin-plated, structure like that of *Rhodocrinites* but having four or five SBrBr in cup; faint median ridge on rays; IBr areas well developed; anal area contains extra plates and lacks a basal concavity (163). **Ord.** (Chazyan, Mohawkian).

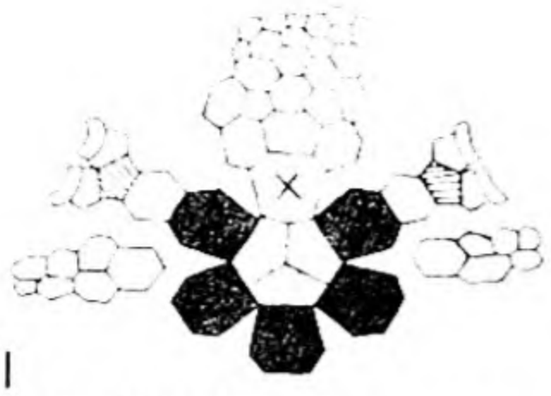
A. desideratus W. R. Billings [73—14] (163). **Trenton:** Ont.

PAULOCRINUS Springer 1926

(**P. biturbinatus*). Cup high, steeply conical, widest at arm bases, tegmen high, conical, grading into anal tube; plates nodose, stellate (142). **Sil.** (Niagaran).

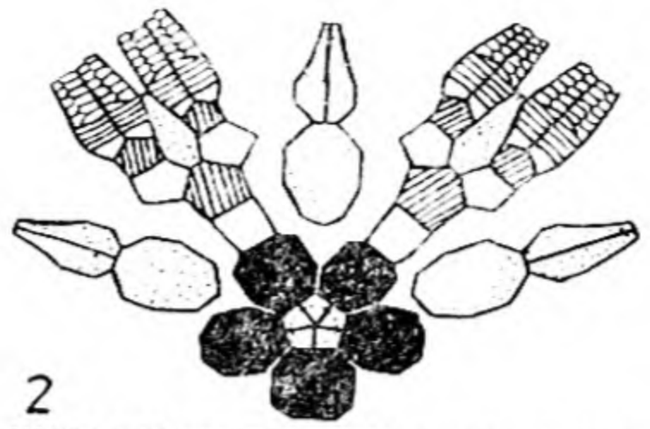
PLATE 70

Analyses of representative crinoids belonging to the subclass Camerata (RR black, XX and IBrBr stippled, AxAx oblique-ruled).



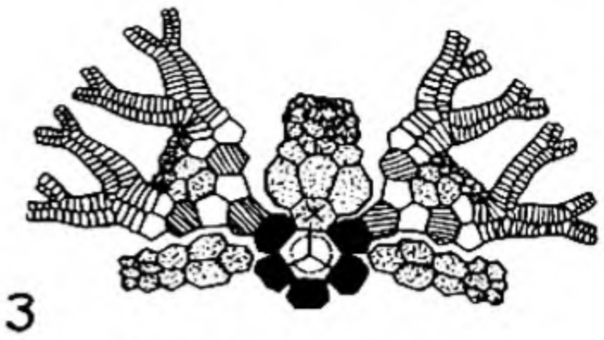
1

SACCOCRINUS—Monocyclic. BB 3. RR 5 plus X. PBrBr two. PBr_1 hexagonal. Arms 10-20. Fewer than in Periechocrinus.



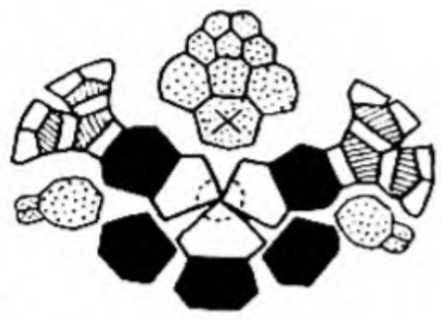
2

EUCALYPTOCRINITES—Monocyclic. Base invaginated. BB 4. No anal plates. Arms in compartments.



3

MEGISTOCRINUS—Monocyclic. BB 3. Base flat. Calyx bowl-shaped. ISBr areas widely expanded. Biserial branching arms.



4

CARPOCRINUS—Monocyclic. BB 3. Anal plates in vertical series. Anal interradius wide. Calyx lobed. Ventral disk flat

5

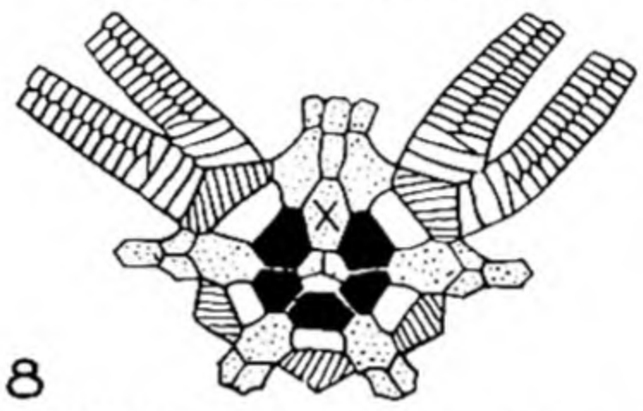
COMPSOCRINUS—Monocyclic. BB 4. ISBrBr and ITBrBr present. Arms uniserial. Plates ornamented.

6

BATOCRINUS—Monocyclic. BB 3. Anus at end of tube. Arms in continuous ring around calyx. Respiratory pores 20.

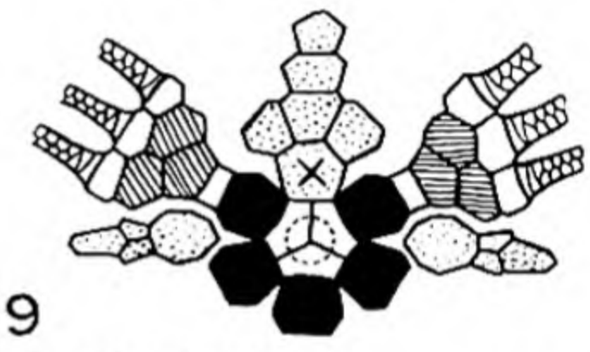
7

EUTROCHOCRINUS—Calyx widely flaring. Wheel-shaped at arm bases. Anus at end of tube. IBrBr in contact with IAmb Amb at anal side.



8

AGARICOCRINITES—Base flat. Arms large, oval, laterally directed. Anus opens directly through tegmen.



9

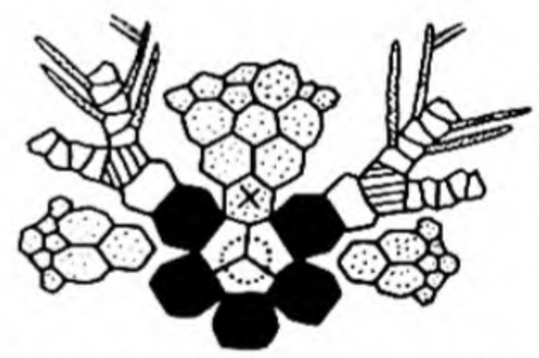
DORYCRINUS—Arms grouped. Anus opens directly through tegmen. Ventral disk spinose.

10

ACTINOCRINITES—Long anal tube, central. IBr Br widely connected with IAmbAmb. Normal biserial arms.

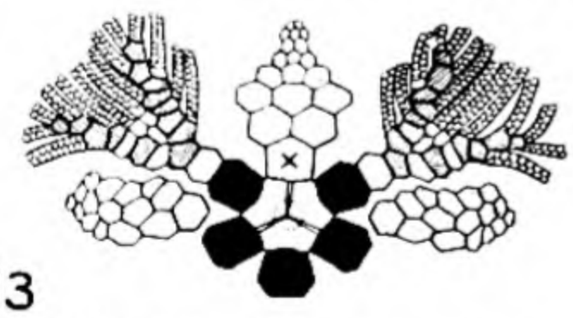
11

CACTOCRINUS—Long sub central anal tube. Arms in continuous ring. All BrBr above PBrBr axillary.



12

STEGANOCRINUS—Anus opens at end of tube. Arms given off from tube like extensions.



13

TELEIOCRINUS—Long central anal tube. Arms incorporated in calyx forming broad flaring rim.

14

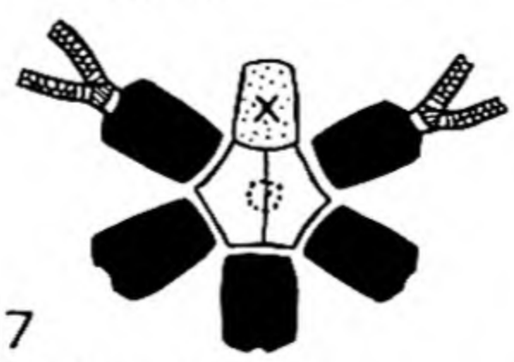
STROTOCRINUS—Multiple branching brachials form widely flaring rim to calyx. Anus opens directly through tegmen.

15

PHYSETOCRINUS—Anus opens directly through tegmen. Arms grouped. IAmb areas usually depressed.

16

MARSUPIOCRINUS—Calyx depressed, bowl-shaped. PBr one, small, triangular. SBr_1 rests on both PBr and R. Column round.



17

DICHOCRINUS—BB 2. RR 5 plus X. Arms come off constricted upper surface of RR.

18

PLATYCRINITES—BB 3, unequal. RR 5. No anal plates in calyx. Arms come off constricted upper surface of RR. Column elliptical, twisted.

***P. biturbinatus** Springer [72—20]. Only known species (142). **Laurel:** Ind.

WILSONICRINUS Springer 1926

(**W. discoideus*). Cup low, conical, sides widely flaring; IBB four; tegmen about equal in convexity to dorsal cup (142). **Sil.** (Niagaran).

***W. discoideus** Springer [72—26]. Only known species (142). **Laurel:** Ind.

SPHAEROTOCRINUS Goldring 1923

(**S. ornatus*). Calyx globose, higher than wide, base not truncate; PBr one; tegmen arched anus at end of tube; all plates sculptured (25). **Dev.** (Helderberg).

***S. ornatus** Goldring [72—24]. Only known species (25). **Lewistown:** Pa.

THYLACOCRINUS Oehlert 1878

(**T. vannoiti*). Cup unusually large, globose, widest at arm bases, plates decreasing in size regularly from base upward; PBrBr two, SBrBr two, TBrBr four in cup; extra plates in anal area; ISBrBr and ITBrBr present (25). **Dev.**

T. clarkei Wachsmuth and Springer [72—27] (25). **Hamilton:** N. Y.

RHODOCRINITIDAE. Dicyclic; RR separated all around; median ray ridges present only in primitive genera; IBrBr regular, not depressed; anal area reduced in size and lacking median ridge; cup rounded, globular, having basal concavity. **Ord.–Miss.**

DIABOLOCRINUS

Wachsmuth and Springer 1897

(**D. perplexus*). Calyx globular, basal concavity deep, structure like that of *Rhodocrinites*; anus opens directly through tegmen; arm openings unusually large (163). **Ord.** (Chazyan).

D. vesperalis (White) [72—16] (163). **Ottosee:** Tenn.

***D. perplexus** W and S [72—15]. Differs from *D. vesperalis* in having irregular triangular plates in lower part of cup (163). **Ottosee:** Tenn.

PARAGAZACRINUS Springer 1926

(**P. rotundus*). Calyx globular, structure similar to that of *Rhodocrinites* but tegmen divided into compartments, surmounted by a high central spine (142). **Sil.** (Niagaran).

***P. rotundus** Springer [72—25]. Only known species (142). **Laurel:** Ind.

EMPEROCRINUS Miller and Gurley 1895

(**E. indianensis*). Cup small, low, sides broadly expanding, bowl-shaped, distinctly lobed at arm bases; IBB five, confined to basal concavity; a single large IBr in cup (162). **Sil.** (Niagaran).

***E. indianensis** M and G [72—14]. Only known species (142). **Laurel:** Ind.

LYRIOCRINUS Hall 1852

(**Marsupiocrinites? dactylus* Hall). Cup large, globose, considerably wider than high, having almost perfect pentamerous symmetry; IBB five, small, in basal concavity; PBrBr two, SBrBr two, followed by long stout simple biserial arms; IBrBr normally one, two, one; tegminal plates not rising above dorsal cup (163). **Sil.** (Niagaran).

L. melissa (Hall) [72—28] (142). **Waldron:** Ind.

ACANTHOCRINUS Roemer 1850

(**A. longispina*). Calyx globose, structure as in *Rhodocrinites*; a long slender spine borne by each lower plate of cup; tegmen constricted (163). **Dev.**

A. spinosus (Hall) [72—13] (25). **Hamilton:** N. Y.

RHODOCRINITES Miller 1821 [70—8]

(**R. verus*). Calyx globose; IBB in basal concavity; extra plates in anal area; tegmen constricted, anus opening directly through tegmen; the most abundant genus of family, distinguished from *Gilbertsocrinus* by arm structure and width of tegmen (163). **Dev., Miss.**

R. watersianus (Wachsmuth and Springer) [73—8]. Plates smooth; four arms to ray (74, 78). **Miss.:** Ia. (Hampton, Gilmore City).

R. kirbyi (Wachsmuth and Springer) [73—12]. Cup conical; plates stellate; IBrBr numerous (78). **Miss.:** Ia. (Hampton).

R. cavanaughi (Laudon) [73—10]. Cup low, rounded; anal pyramid low; plates stellate (74). **Miss.:** Ia. (Gilmore City).

R. douglassi serpens (Laudon) [73—9]. Cup constricted at top; tegmen pentagonal, flat; arms directed laterally (74). **Miss.:** Ia. (Gilmore City).

R. tuberculatus (Wachsmuth and Springer) [73—6]. Widest at base, at level of RR, which bear large projecting nodes (163). **Miss.:** N. Mex. (Lake Valley).

R. wortheni (Hall) [73—11]. A smooth-plated form similar to *R. watersianus* but having six arms to the ray instead of four (74). **Miss.:** Ia. (Gilmore City, Burlington).

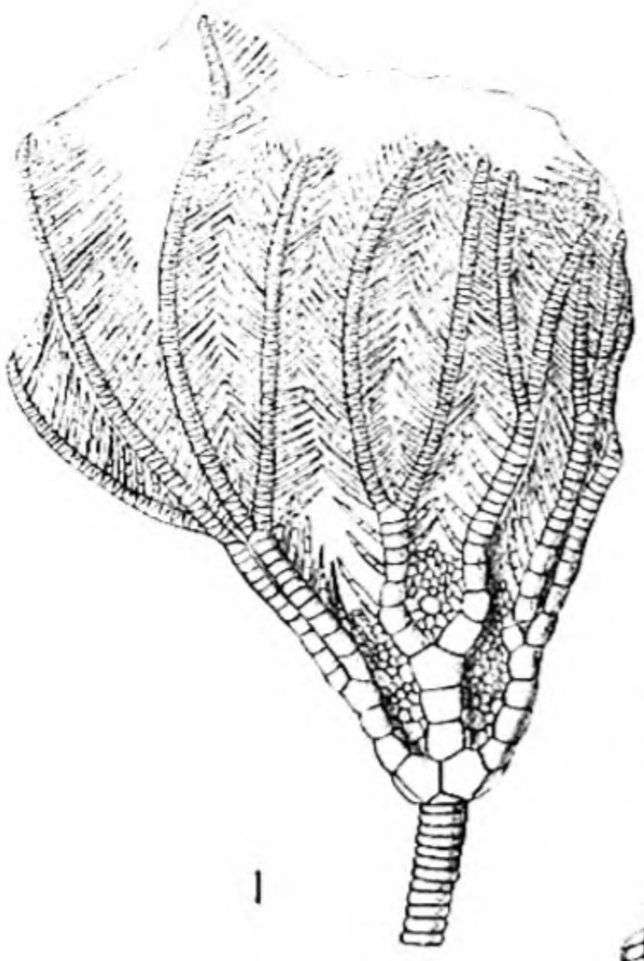
R. barrisi (Hall) [73—7]. Plates unusually spinose, long spines on RR projecting downward. **Miss.:** Ia. and Mo. (Burlington), Mo. (Reeds Springs), N. Mex. (Lake Valley).

GILBERTSOCRINUS Phillips 1836 [70—4]

(**G. calcaratus*). Calyx structure like that of *Rhodocrinites*; tegmen equal in width to dorsal cup, or flaring slightly beyond it, margins passing outward into tubular appendages that normally hang pendent

PLATE 71

Analyses of representative crinoids belonging to the subclass Camerata (RR black, XX and IBrBr stippled, AxAx oblique-ruled).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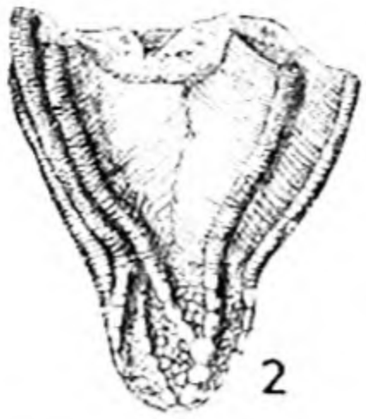
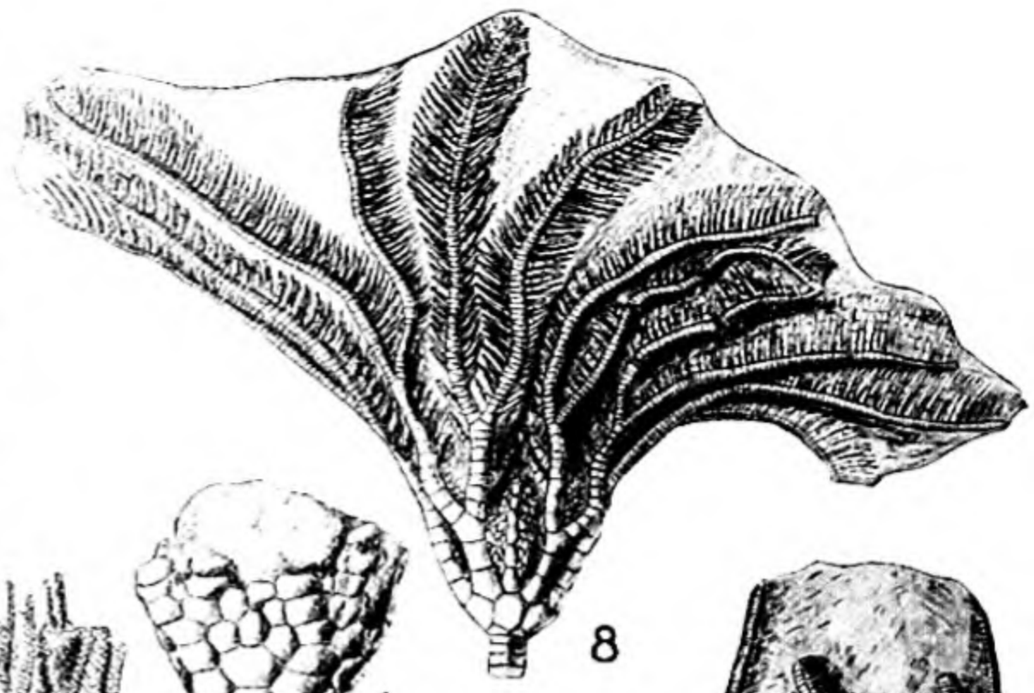

2

3

9a

9b


8

4

5

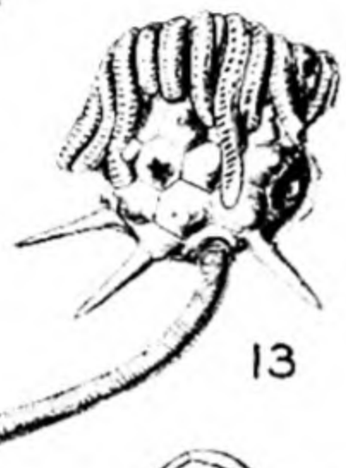
7

6

11a

11b

12a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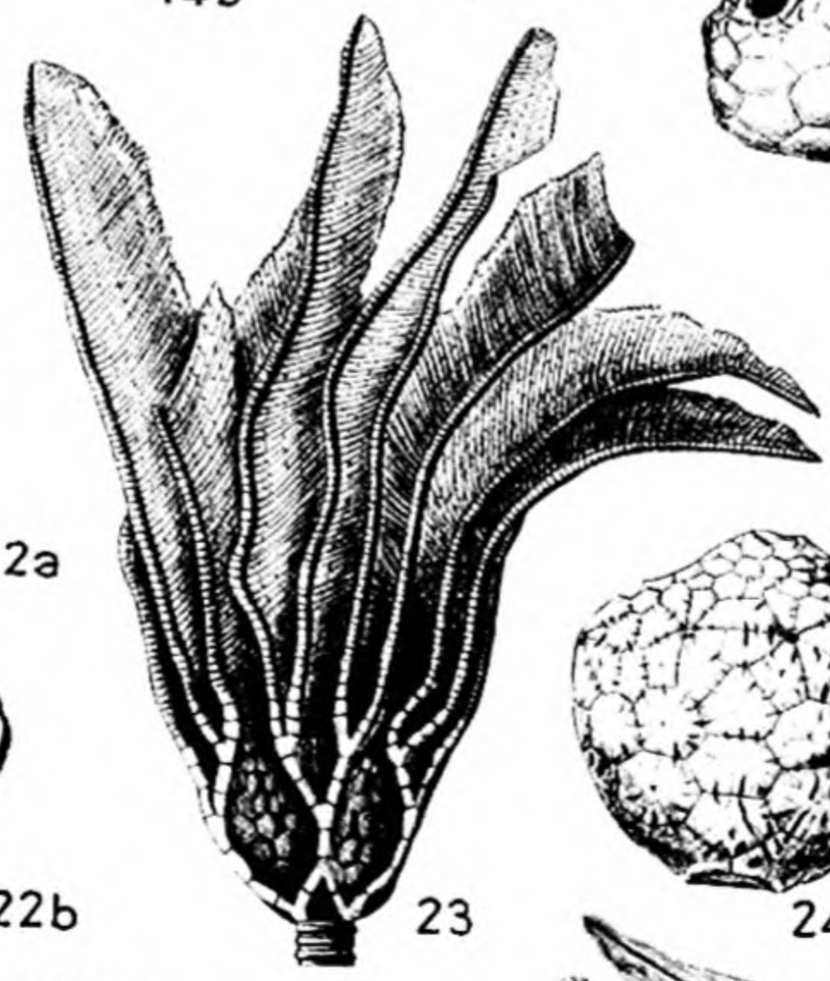
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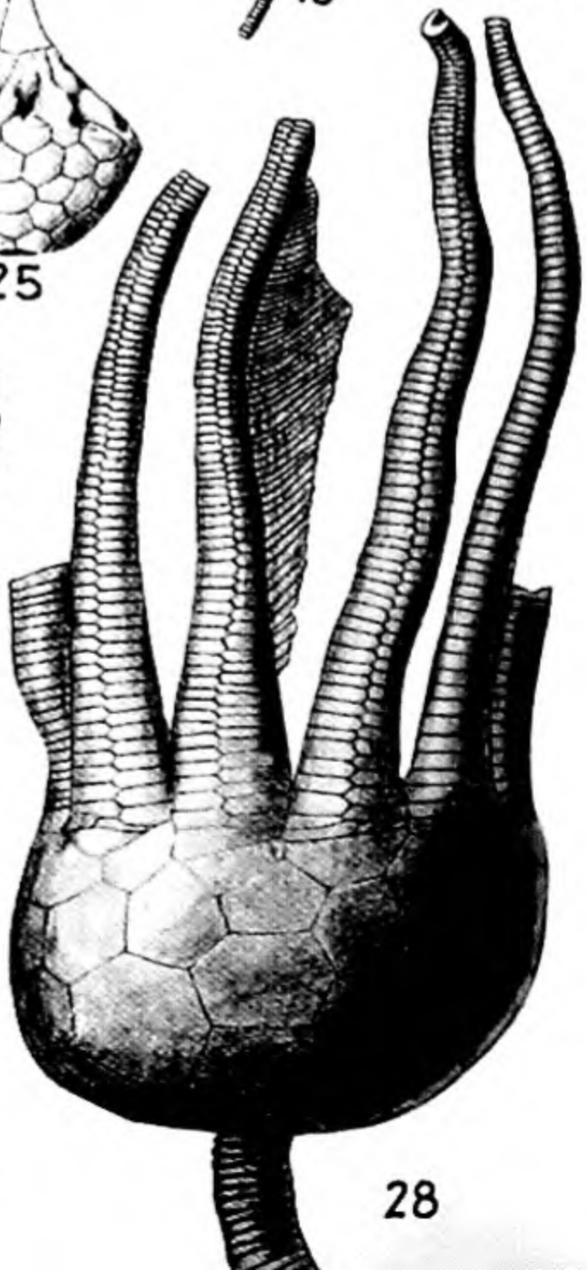
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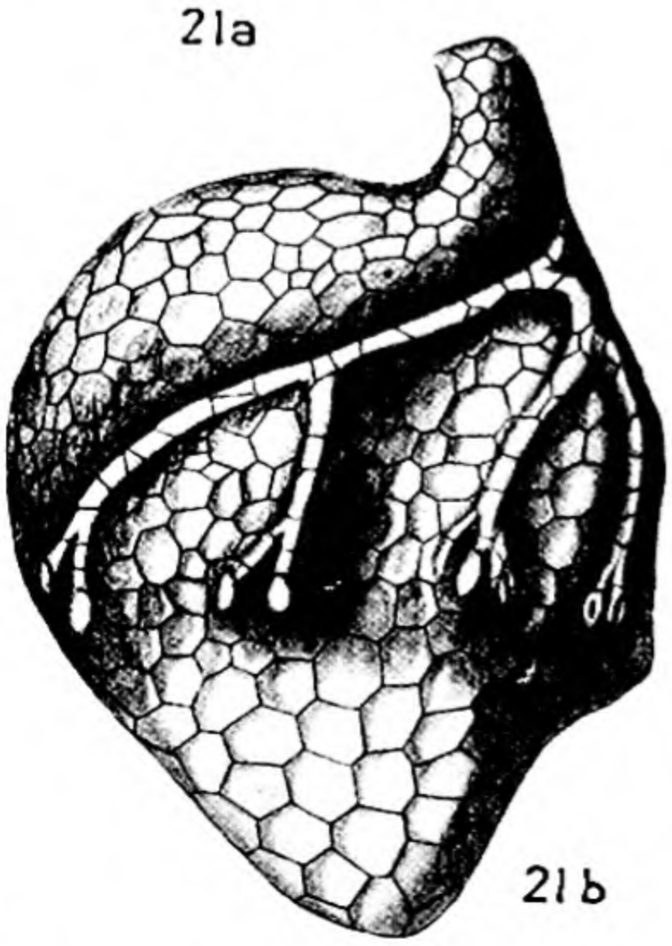
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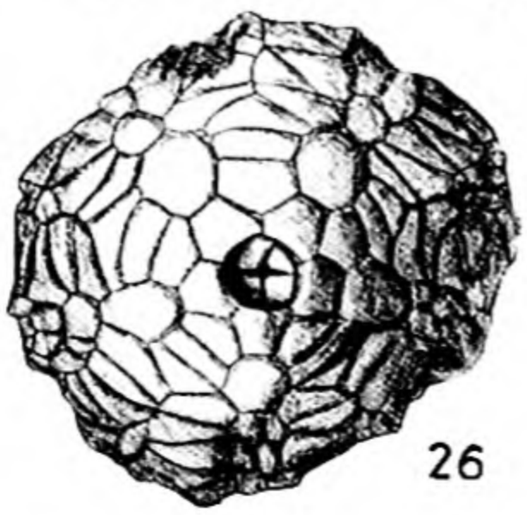
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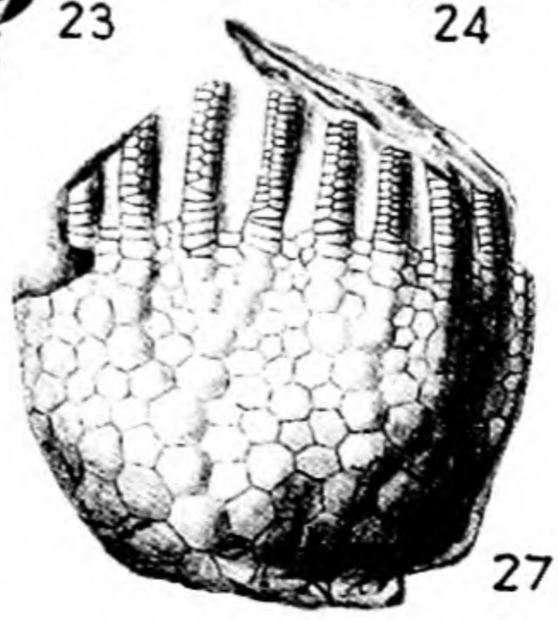
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at sides of cup; arms small, delicate, relatively inconspicuous (163). **Dev., Miss.**

G. spinigerus (Hall) [**73**—5]. Sharp spines on RR and conspicuous ridges on rays (25). **Dev.:** Ont. (Hamilton).

G. fiscellus (Meek and Worthen) [**73**—4]. Cup small, low bowl-shaped (163). **Miss.** (Burlington): Ia., Mo.

G. typus (Hall) [**73**—3]. Cup large, much elongated, plates spinose (163). **Miss.** (Burlington): Ia., Mo.

G. tuberosus (Lyon and Casseday) [**73**—1, 2]. Tegmen expanded, bearing ponderous tubular appendages; plates of cup spinose (163). **Miss.:** Ind. (Keokuk).

PTYCHOCRINIDAE. Dicyclic; RR in contact except at anal side; median ray ridges well developed; IBrBr regular, depressed; anal area divided by median ridge; arms uniserial. **Ord.**

PTYCHOCRINUS

Wachsmuth and Springer 1885 [**70**—9]

(**Gaurocrinus splendens* S. A. Miller). Similar to *Reteocrinus* in having a median ridge on rays and depressed IBr areas, but differentiated by regular IBrBr, elevated anal area that lacks a median ridge, and by fewer fBrBr in cup; plates stellate; arms uniserial, branching isotomously (163). **Ord., Sil.**

***P. splendens** (S. A. Miller) [**72**—19] (163). **Sil.:** Mo. (Girardeau).

DIMEROCRINITIDAE. Dicyclic; RR in contact except at posterior side; IBrBr regular, not markedly depressed; anal area lacking median ridge, differentiated by extra plates; median ray ridge faintly developed in primitive genera. **Sil.–L. Dev.**

EUDIMEROCRINUS Springer 1926 [**70**—3]

(**E. multibrachiatus*). Like *Dimerocrinites* but arms branch above calyx (142). **Sil.** (Niagaran).

***E. multibrachiatus** Springer [**72**—6]. Only known species (142). **Beech River:** Tenn.

DIMEROCRINITES Phillips 1839

(**D. decadactylus*). Cup elongate; anal area slightly expanded, X followed by three in second range; median ridge on rays absent; IBr areas not depressed; arms biserial, not branching above calyx (163). **Sil., Dev.**

D. inornatus (Hall) [**72**—4] (142). **Sil.:** Ind. (Waldron).

D. planus (Springer) [**72**—7]. Cup smooth, rounded; BB not projecting downward (142). **Sil.:** Tenn. (Beech River).

D. arborescens (Talbot) [**72**—5]. Small form; cup not strongly conical (25). **Dev.:** N. Y. (Coeymans).

CYPHOCRINUS S. A. Miller 1892

(**C. gorbyi*). Like *Dimerocrinites* but cup low, wide, broadly flaring, sides curving from narrow base to downward directed arms; tegminal plates spinose (142). **Sil.** (Niagaran).

***C. gorbyi** S. A. Miller [**72**—12] (142). **Laurel:** Ind.

PTERINOCRINUS Goldring 1923

(**P. quinquenodus*). Like *Dimerocrinites* but arms uniserial (25). **Dev.**

***P. quinquenodus** Goldring [**72**—22]. Only described species (25). **Chemung:** N. Y.

LAMPTEROCRINIDAE. Dicyclic; IBB, BB, and RR large; RR in contact except at anal side; anal area marked by extra plates, bulging markedly at arm levels and on tegmen; IBrBr few, small; anus opens through tube; arms grouped. **Sil.**

LAMPTEROCRINUS Roemer 1860 [**70**—2]

(**L. tennesseensis*). Cup high, subturbinate; anal interradius bulging, anal tube strong; IBrBr few; rays produced into five tubular extensions that bear uniserial pinnulate arms; column pentagonal (142). **Sil.** (Niagaran).

***L. tennesseensis** Roemer [**72**—18] (142). **Beech River:** Tenn.

L. roemeri Springer [**72**—17]. Surface ornamentation simple (142). **Beech River:** Tenn.

SIPHONOCRINUS S. A. Miller 1888

(**Glyptocrinus nobilis* Hall). Cup large, expanding rapidly; IBr area depressed; tegmen high, anal side greatly inflated, anal tube long; arms grouped, projecting (163). **Sil.** (Niagaran).

***S. nobilis** (Hall) [**72**—21]. Cup steeply conical;

PLATE 72

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1. Reteocrinus nealli (163) (x2). Ant. **2. Xenocrinus baeri** (163). Post. **3. Tanaocrinus typus** (163). Post. **4, 5. Dimerocrinites** spp. **4. D. inornatus** (142). Post. **5. D. arborescens** (25), type. Post. **6. Eudimerocrinus multibrachiatus** (142). Ant. **7. Dimerocrinites planus** (142). Lat. **8. Reteocrinus nealli** (163). Post. **9–11. Gazacrinus** spp. **9a–c. G. stellatus** (142). Post., ant., dorsal. **10. G. ramifer** (142). Ant. **11a, b. G. inornatus** (142). Ant., post. **12a, b. Cyphocrinus gorbyi** (142). Lat., dorsal. **13. Acanthocrinus spinosus** (25), type. Lat. **14a, b. Emperocrinus indianensis** (142). Dorsal, ventral. **15, 16. Diabolocrinus** spp. **15. D. perplexus** (142). Dorsal. **16. D. vesperalis** (163). Lat. **17, 18. Lampterocrinus** spp. **17. L. roemeri** (142). Lat. **18. L. tennesseensis** (142). Left ant. **19. Ptychocrinus splendens** (163). Lat. **20. Paulocrinus biturbinatus** (142). Right post. **21a, b. Siphonocrinus nobilis** (163). Ventral, right lat. **22a, b. Pterinocrinus quinquenodus** (25). Lat.; post. (x2). **23. Rhaphanocrinus sculptus** (163). Lat. **24. Sphaerotocrinus ornatus** (25) (x3). Ant. **25. Paragazacrinus retundus** (142). Lat. **26. Wilsonicrinus discoideus** (142), type. Dorsal. **27. Thylacocrinus clarkei** (25). Lat. **28. Lyriocrinus melissa** (163). Lat.

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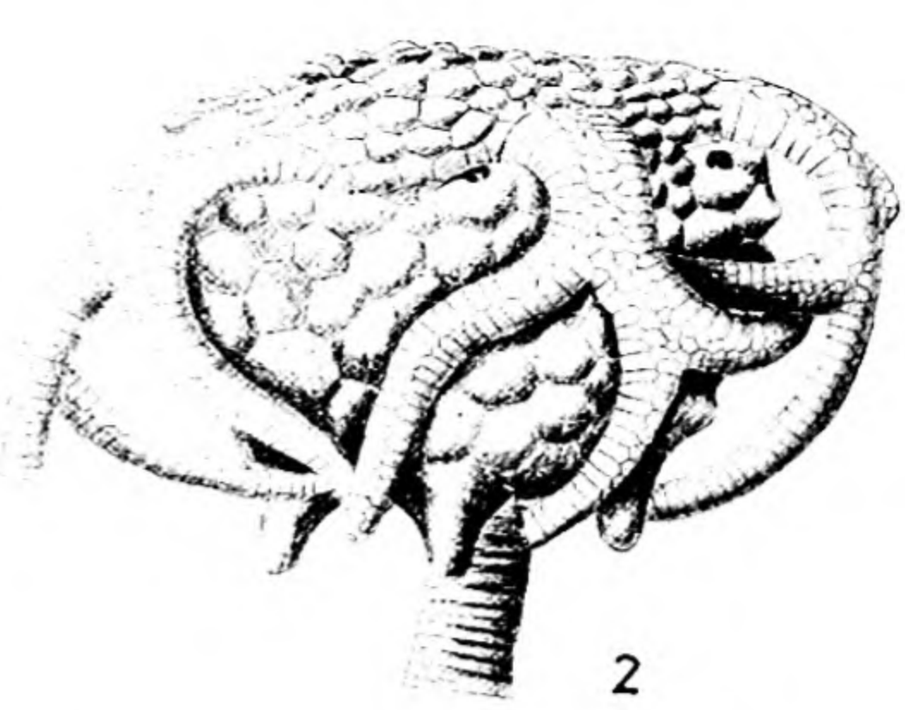
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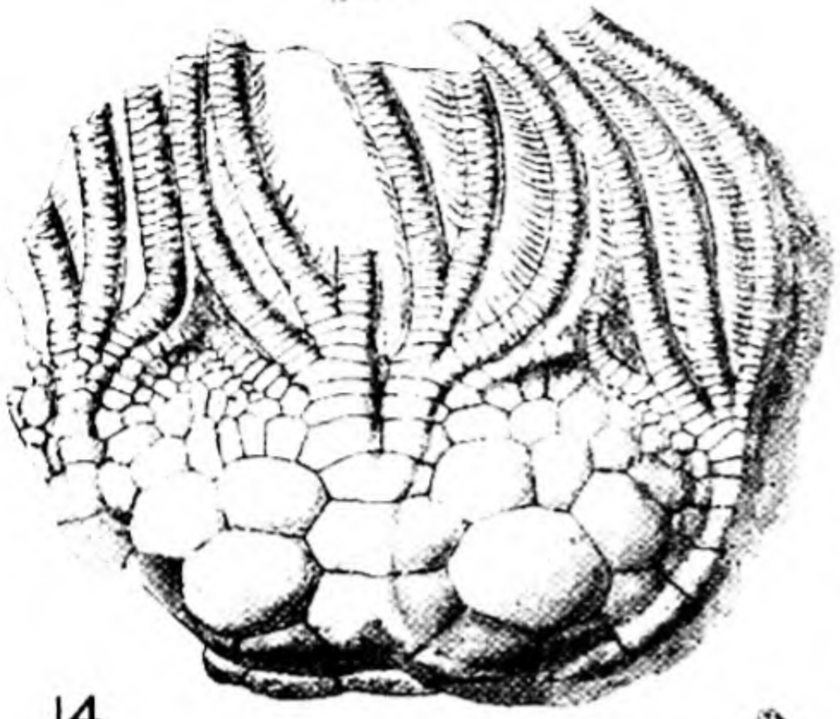
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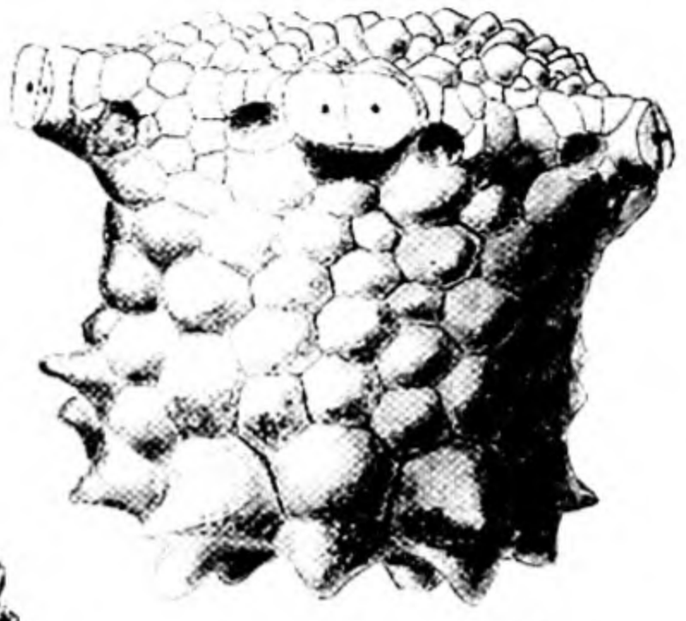
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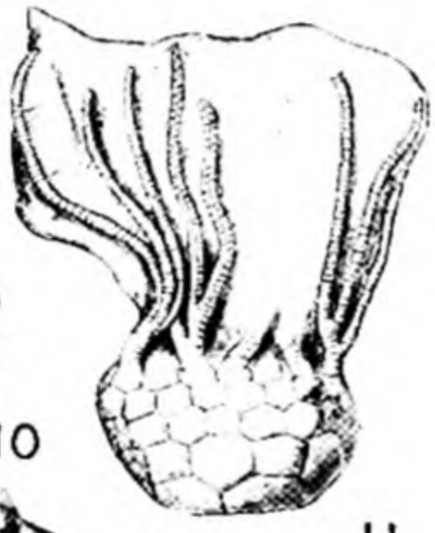
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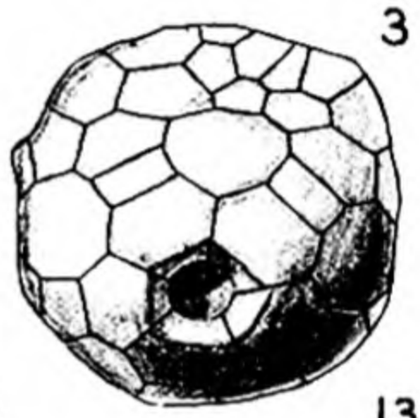
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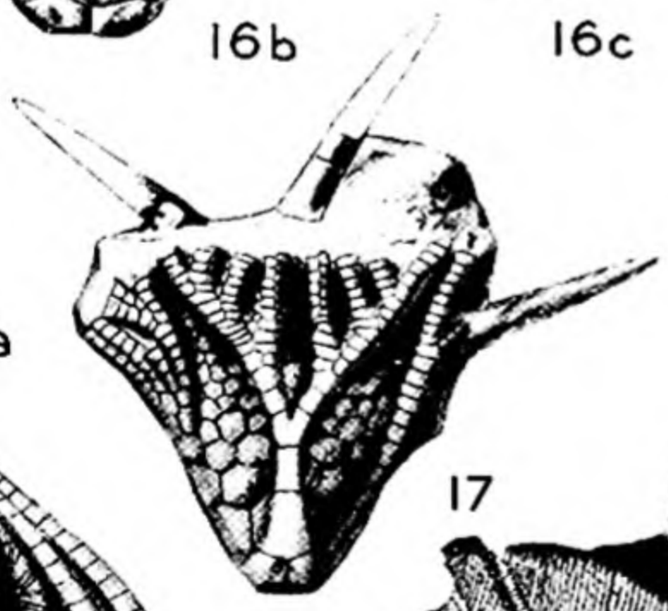
16c

16b

16a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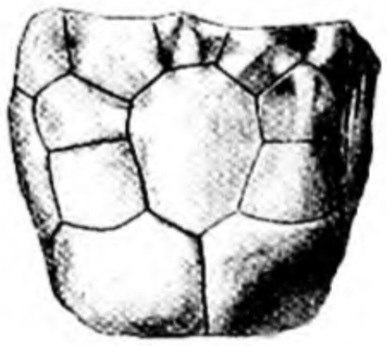
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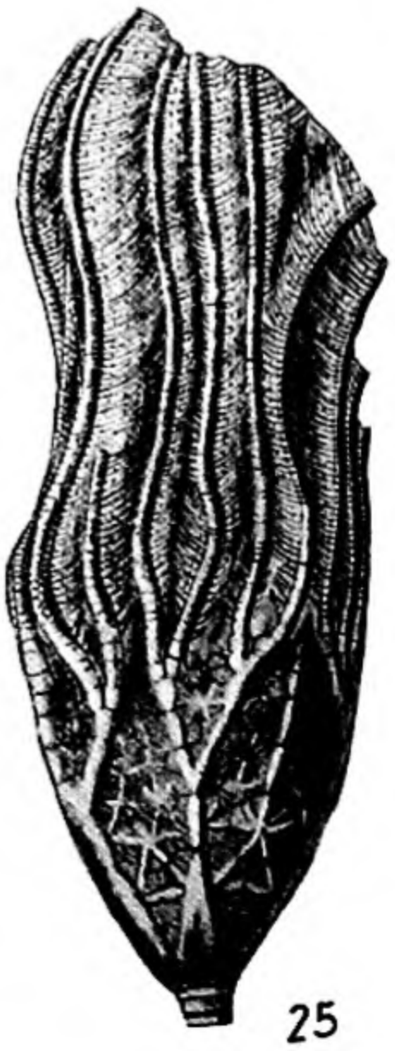
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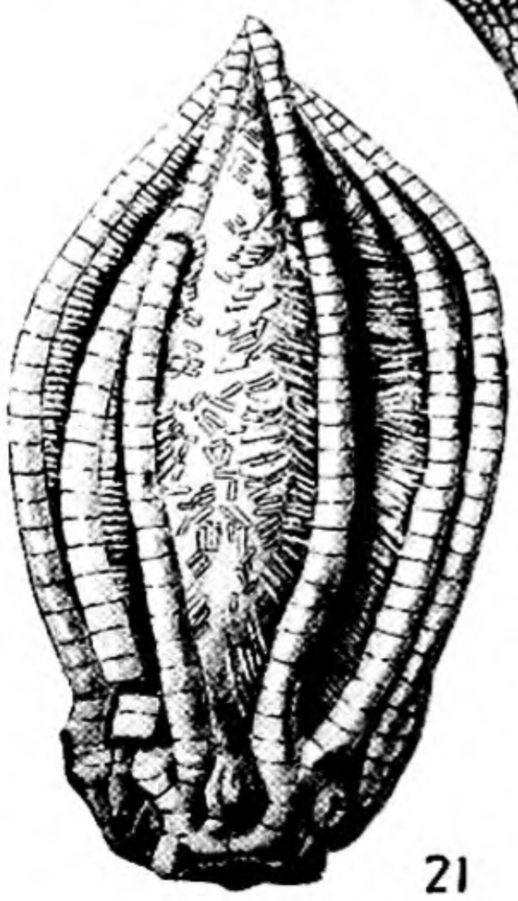
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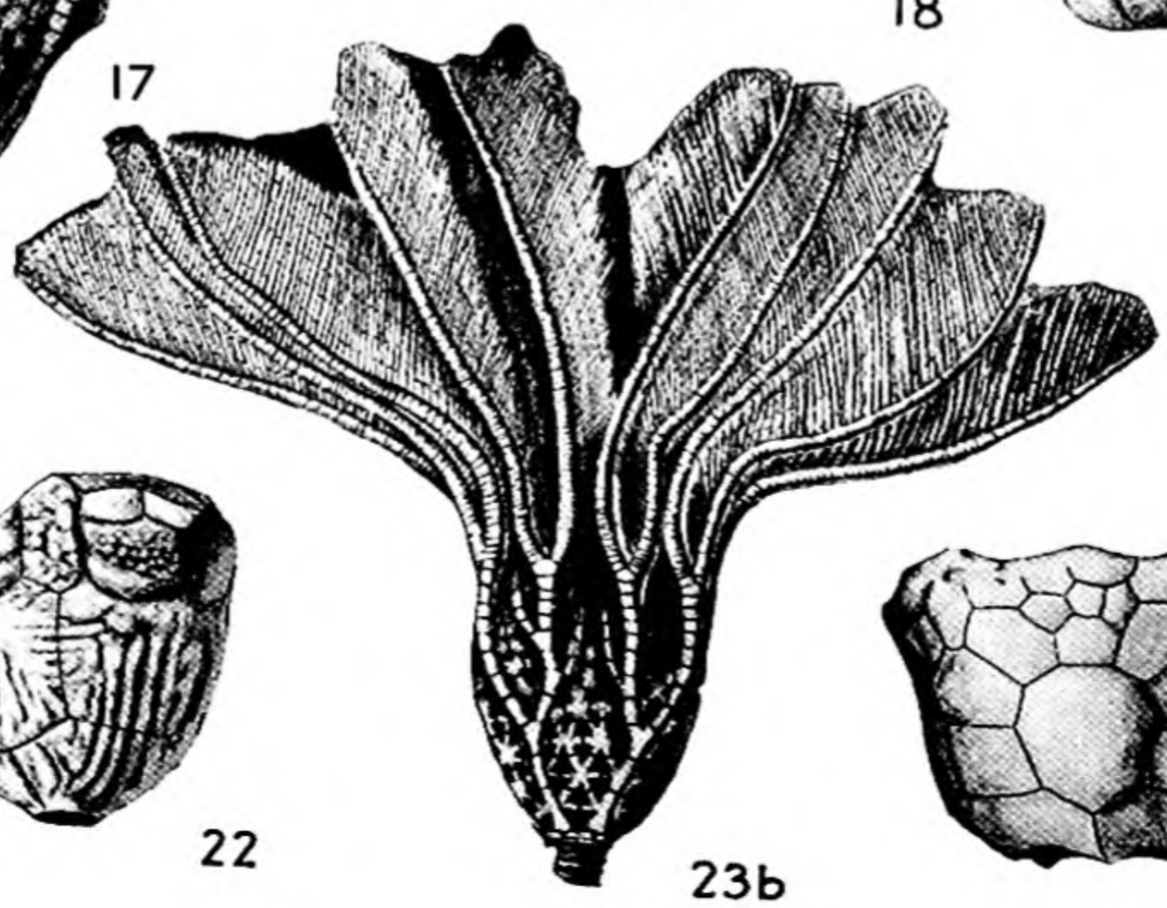
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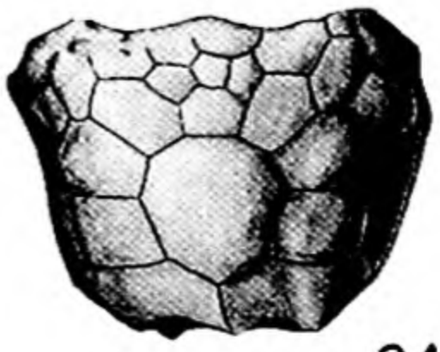
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anal tube directed vertically (163). **Racine:** Ind., Wis., Ill., Ia.

GAZACRINIDAE. Dicyclic; RR in contact except at anal side; a single IBr in each interray; cup composed of few plates; tegmen formed by five small OO. **Sil.**

GAZACRINUS S. A. Miller 1892 [**70**—5]

(**G. inornatus*). Small simple forms, not closely related to other genera referred to Dimerocrinitidae; base concave, IBB confined to cavity; BB five, PB truncate, supporting X; RR five; a single IBr connects with tegmen plates; arms biserial, unbranched (142). **Sil., Dev.**

***G. inornatus** S. A. Miller [**72**—11]. Cup high conical, smooth (142). **Laurel:** Ind.

G. ramifer (Roemer) [**72**—10] (142). **Sil.:** Tenn. (Beech River).

G. stellatus Springer [**72**—9]. Cup low, plates stellate (142). **Dev.:** Tenn. (Linden).

NYCTOCRINIDAE. Dicyclic; RR in contact all around; no X or IBrBr in cup; anus at end of long spinose tube; free arms arise from upper edges of RR as in *Platycrinites*; arms biserial, branching. **Sil.**

NYCTOCRINUS Springer 1926

(**N. magnitubus*). Dicyclic; IBB five; BB five, small; RR five, large, in contact all around; X notched in upper surface of RR; arm facets narrow, arms biserial; long spinose anal tube (142); *Nyctocrinus* is the most highly simplified dicyclic camerate crinoid and approaches most closely to perfect pentamerous symmetry; it corresponds in evolutionary stage to *Platycrinites* among the monocyclic camerate forms. **Sil.** (Niagaran).

***N. magnitubus** Springer [**77**—23] (142). **Beech River:** Tenn.

Order Monobathra. Monocyclic camerate crinoids. **Ord.–Perm.**

XENOCRINIDAE. Monocyclic; primitive form evolved from Reteocrinidae transitional to Desmidocrinidae; BB four or five; RR five, separated all around; anal interradius widely expanded, X in line of RR, followed by plates in vertical rows; strongly developed median ridge on rays; IBr areas depressed; plates stellate. **Ord.**

XENOCRINUS S. A. Miller 1881

(**X. penicillus*). BB four; strong median ridge in anal area; arms 10 stout uniserial (163). **Ord.** (Cincinnatian).

X. baeri (Meek) [72—2] (163). **U. Ord.:** Ohio, Ind.

TANAOCRINIDAE. Monocyclic; BB five; RR in contact except at anal side; conspicuous median ray ridges present; IBrBr depressed; anal area divided by median ridge; plates stellate. **Ord.**

TANAOCRINUS Wachsmuth and Springer 1897

(**T. typus*). Like *Xenocrinus* but BB five instead of four; RR in contact except at anal side, and the arms branch two or three times (163). **Ord.** (Cincinnatian).

***T. typus** Wachsmuth and Springer [**72**—3] (163). **U. Ord.:** Ohio.

COMPSOCRINUS S. A. Miller 1883 [**71**—5]

(**Glyptocrinus harrisi* S. A. Miller). At least five TBrBr are incorporated in dorsal cup; BB four, irregular; RR in contact except at anal side; PBrBr two, SBrBr two, TBrBr numerous; IBr, ISBr and ITBr areas depressed; plates stellate (163). **Ord.** (Cincinnatian).

***C. harrisi** (S. A. Miller) [**75**—20] (163). **U. Ord.:** Ohio.

C. miamiensis (S. A. Miller) [**75**—19] (163). **U. Ord.** Ohio.

PERIECHOCRINITIDAE. Calyx ovoid to globose; BB three, equal; RR five; X in line with RR, followed by three in next circlet; PBr_1 hexagonal; IBrBr numerous, in contact with IAmbAmb; tegmen consisting of many small irregular plates. **Sil.–Miss.**

PERIECHOCRINITES

T. Austin and T. Austin, Jr. 1842 [**70**—17]

(**P. costatus*). Cup high, conical, widest at arm bases, plates elongated, thin; low, slender median ridge on rays; anal opening through tube; arms grouped, branching above calyx (163). **Sil.–Miss.**

P. tennesseensis (Hall) [**75**—15]. A very elongated form (163). **Sil.:** Tenn. (Beech River).

P. whitei (Hall) [**75**—14]. Calyx lower and ex-

PLATE 73

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1–5. Gilbertsocrinus spp. 1, 2. G. tuberosus (163). Ventral, lat. **3. G. typus** (163). Lat. **4. G. fiscellus** (163). Ant. **5. G. spinigerus** (25). Right post. **6–12. Rhodocrinites spp. 6. R. tuberculatus** (163). Post. **7. R. barrisi** (163). Post. **8. R. watersianus** (163). Lat. **9. R. douglassi serpens** (74). Ant. **10. R. cavanaughi** (74). Post. **11. R. wortheni** (163). Lat. **12. R. kirbyi** (163). Lat. **13, 24. Clonocrinus occidentalis** (142). Dorsal, lat. **14. Archaeocrinus desideratus** (163), type. Left post. **15a, b. Cytocrinus laevis** (142). Lat., ventral. **16a–c. Patellocrinus ornatus** (142). Lat. showing arms; lat., dorsal. **17. Thamnocrinus springeri** (25). Left ant. **18. Allocrinus typus** (142). Lat. **19, 20. Laurelocrinus spp. 19. L. wilsoni** (142). Lat. **20a, b. L. paulensis** (142). Lat. **21. Allocrinus longidactylus** (142). Lat. **22. Patelliocrinus rugosus** (142). Right post. **23a, b. Glyptocrinus dyeri** (81). Lat. of immature specimen; lat. of mature specimen. **24.** See 13. **25. Periglyptocrinus billingsi** (163). Left post.

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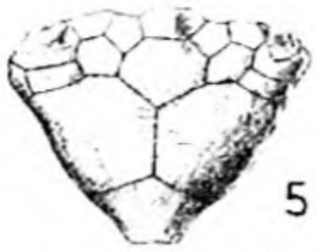
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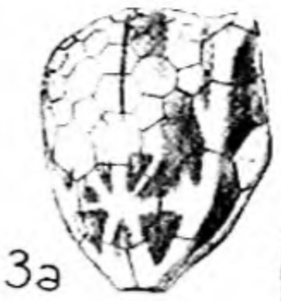
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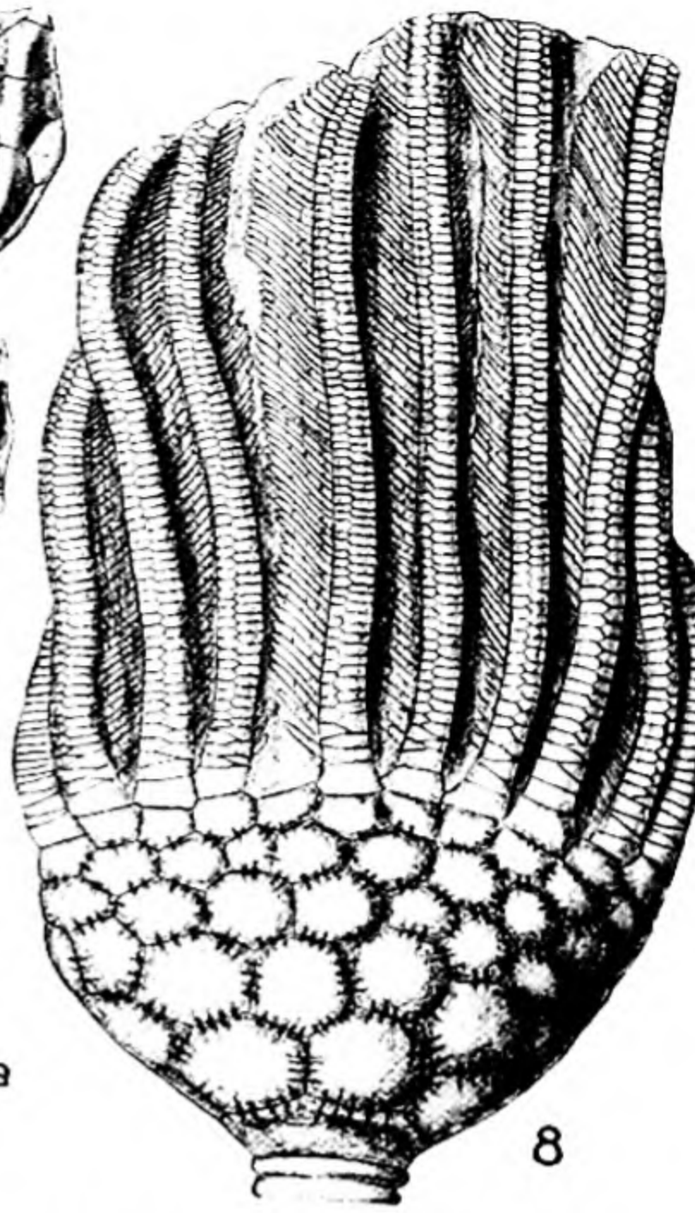
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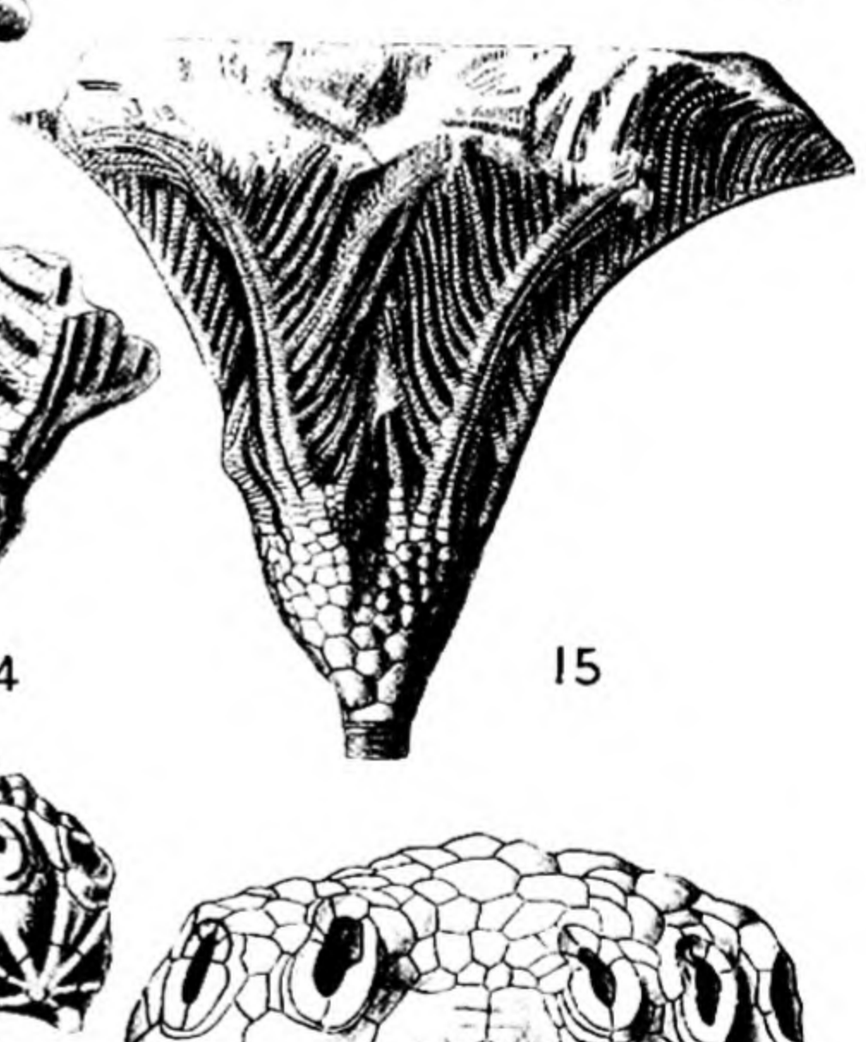
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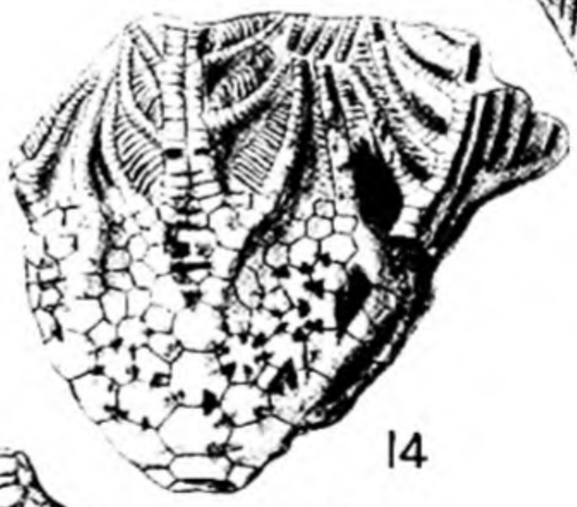
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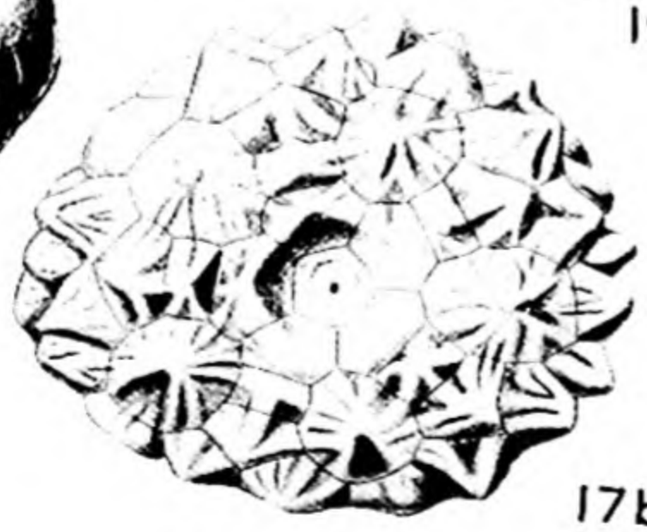
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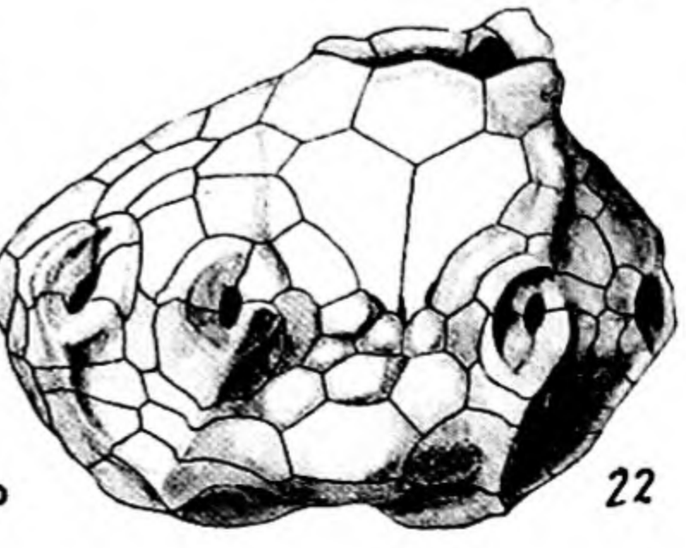
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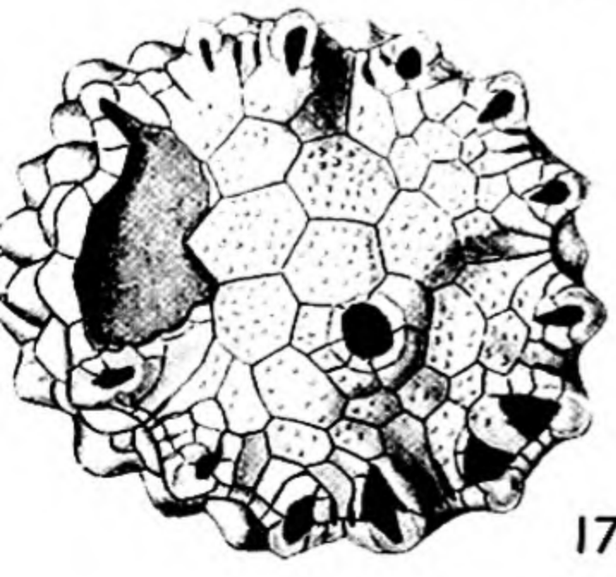
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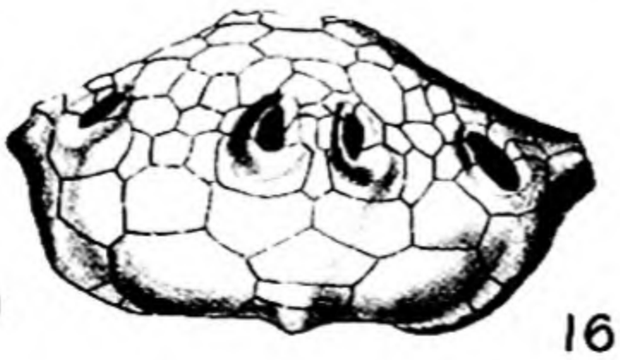

16b

21b

panding much more rapidly than in Silurian species; arms branch at least twice (163). **Miss.:** Ia. (Hampton, Burlington), Mo. (Burlington).

SACCOCRINUS Hall 1852 [71—1]

(**S. speciosus*). Like *Periechocrinites* but fewer and thicker plates in cup and median ridge on rays lacking; anal area wide; SBrBr three, followed by free arms (in North American forms) (163). **Sil.** (N. America)–**L. Carb.** (Europe).

S. benedicti S. A. Miller [75—17] (163). **Sil.:** Ind. (Laurel).

MEGISTOCRINUS

Owen and Shumard 1852 [71—3]

(**Actinocrinus evansii*). Cup bowl-shaped, base flattened, walls expanding slightly, widest at arm bases, plates relatively small and numerous; IBr and ISBr areas broadly expanded; arms biserial, pinnulate, first branching at a considerable distance above the cup (163). **Dev., Miss.**

M. concavus Wachsmuth [75—12]. Concave base and highly nodose plates (163). **Dev.:** Mich. (Traverse.)

M. nodosus Barris [75—10]. Large form with low nodes on plates (163). **Dev.:** Mich. (Traverse), Ia. (Cedar Valley).

M. nobilis Wachsmuth and Springer [75—9]. Large, relatively smooth cup (163). **Miss.:** Ia. (Hampton).

***M. evansii** (O and S) [75—11]. The youngest known form of *Megistocrinus* (163). **Miss.** (Burlington): Ia., Mo.

GENNAEOCRINUS

Wachsmuth and Springer 1881 [70—14]

(**Actinocrinus kentuckiensis* Shumard). Cup conical to bowl-shaped, greatest width at arm bases, strongly lobed, arms clustered, plates thin, highly ornamented; general structure like that of *Megistocrinus* (25). **Dev.**

G. eucharis (Hall) [75—22] (25, 163). **Hamilton:** N. Y.

G. carinatus Wood [75—23]. Surface marked by stellate ribs normal to sutures, irregular projecting spines on BB and RR (25). **Hamilton:** N. Y.

COROCRINUS Goldring 1923

(**C. ornatus*). Cup ovoid, high; BB three, forming a narrow cone; RR five; X in line with RR, followed by three in next range, anal interradius widely expanded; PBrBr two; rays marked by a strong median ridge; arms 20, uniserial; plates markedly stellate. **Dev.**

***C. ornatus** Goldring [74—3]. Only known species (25). **Hamilton:** N. Y.

THAMNOCRINUS Goldring 1923 [70—13]

(**T. springeri*). Cup steeply conical; rays marked by a strong median ridge; tegmen highly arched, spinose, IAmb areas depressed; arms long, compact, biserial, endotomous, ending in 10 main branches to each ray; distinguished mainly on the basis of arm structure (25). **Dev.**

***T. springeri** Goldring [73—17] (25). **Hamilton:** N. Y.

AMPHORACRINIDAE. Monocyclic; BB 3, equal; RR in contact except at anal side; PBr_1 hexagonal; X followed by three plates in next circlet; base flat to concave; anus opens directly through tegmen. **Miss.** (Osage).

AMPHORACRINUS Austin 1848

(**Actinocrinus gilbertsoni* Miller). Base flattened, truncate; arms grouped, laterally directed; tegmen greatly inflated; anal tube short, eccentric; distinguished readily from actinocrinitids by its flattened base and three plates following X in next circlet (163). **Miss.** (Kinderhook, Osage).

A. divergens (Hall) [77—28] (163). **Burlington:** Ia., Mo.; **Lake Valley:** N. Mex.

ACTINOCRINITIDAE. Monocyclic; BB three, equal; RR in contact except at anal side; PBr_1 hexagonal; X followed by two plates in next circlet. **Miss.** (Kinderhook, Osage).

CACTOCRINUS

Wachsmuth and Springer 1897 [71—11]

(**Actinocrinus proboscidialis* Hall). Calyx bilobate, tegmen almost equal to height of dorsal cup; IBrBr not in contact with IAmbAmb; all BrBr above PBrBr axillary; anus at end of tube; plates normally stellate; arms simple, biserial (163). **Miss.** (Kinderhook, Osage).

C. arnoldi (Wachsmuth and Springer) [77—4] (78). **Hampton:** Ia.

C. imperator Laudon [76—8]. Large; fine stellate markings (74). **Gilmore City:** Ia.

***C. proboscidialis** (Hall) [77—3] (163). **Burlington:** Ill., Ia., Mo.

C. multibrachiatus (Hall) [77—2]. Arms 36 to 40 to the ray (163). **Burlington:** Ia., Mo.; **Lake Valley:** N. Mex.

PLATE 74

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1. Clarkeocrinus troosti (25). Lat. **2a, b. Allsocrinus laevis** (142). Post., right post. **3a–c. Corocrinus ornatus** (25). Post views. **4–7. Macrostylocrinus spp. 4. M. laevis** (142). Lat. **5. M. striatus** (163). Lat. **6a, b. M. granulosus** (142). Post. views. **7. M. fasciatus** (142). Post. **8. Technocrinus andrewsi** (162), type. Lat. **9. Melocrinites bainbridgensis** (25.) Left ant. **10. Melocrinites nodosus** (25). Post. **11, 12. Ctenocrinus spp. 11. C. pachydactylus** (25) (x2). Lat. **12. C. paucidactylus** (25). Lat. **13. Macrostylocrinus ornatus** (142), type. Lat. **14, 15. Ctenocrinus spp. 14. C. pachydactylus** (25). Lat. **15. C. nobilissimus** (25), type. Lat. **16–22. Dolatocrinus spp. 16a, b. D. speciosus** (163). Dorsal, lat. **17a, b. D. lyoni** (163). Ventral, dorsal. **18. D. bulbaceus** (133). Lat. **19. D. argutus** (133). Lat. **20. D. lacus** (163), type. Ant. **21a, b. D. bellulus** (133). Lat., dorsal. **22. D. marshi** (163), type. Post. **23. Stereocrinus triangulatus** (163). Lat.

1a

1b

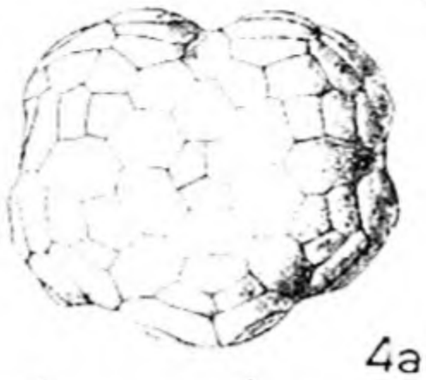
3

5a

6

2a

2b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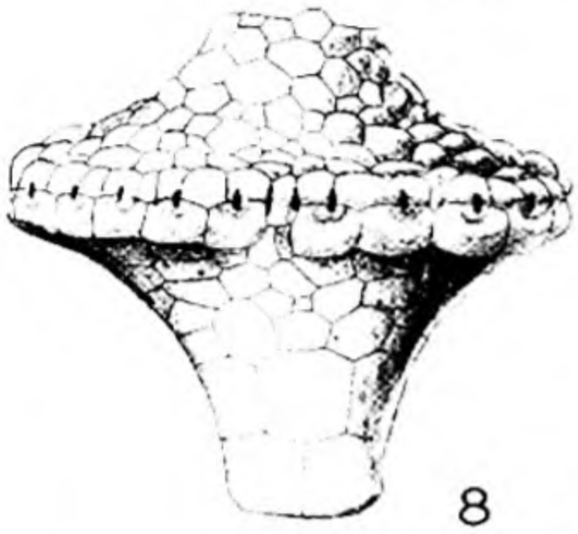
4b

7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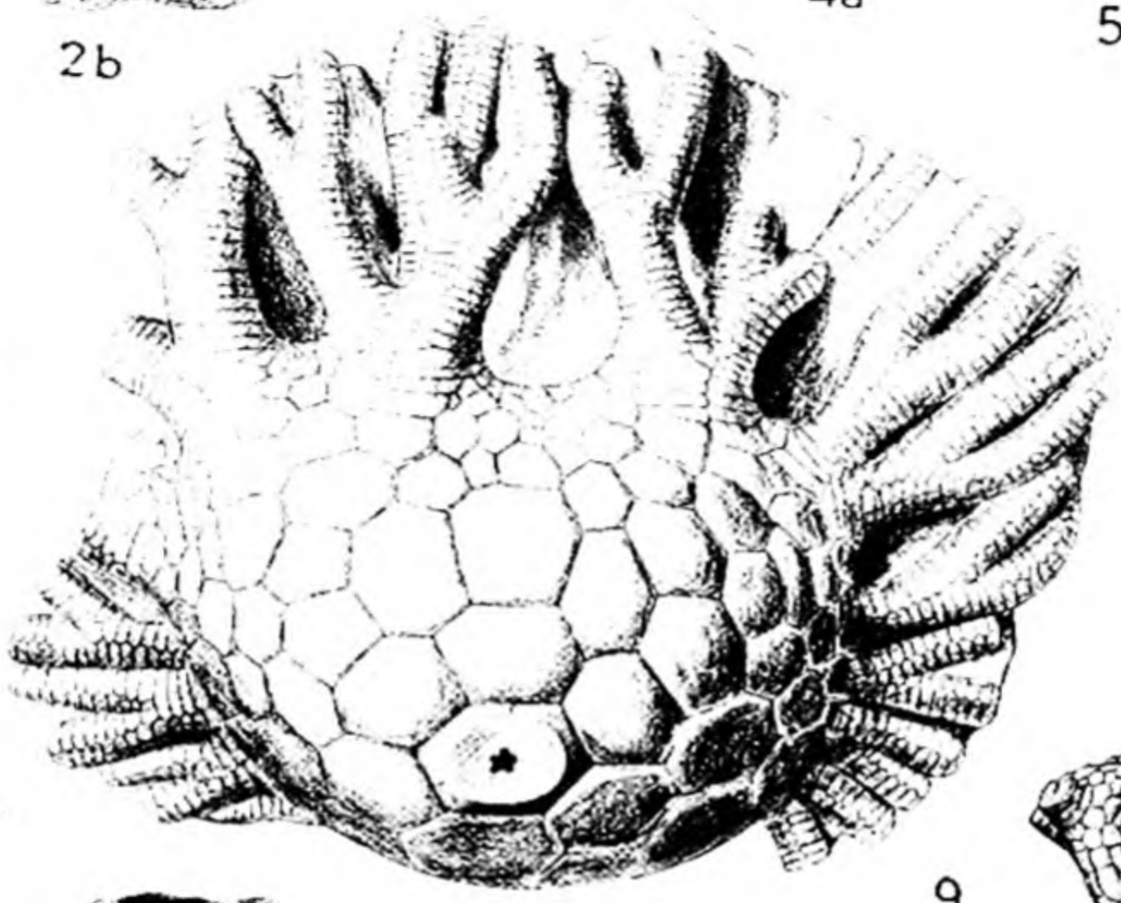
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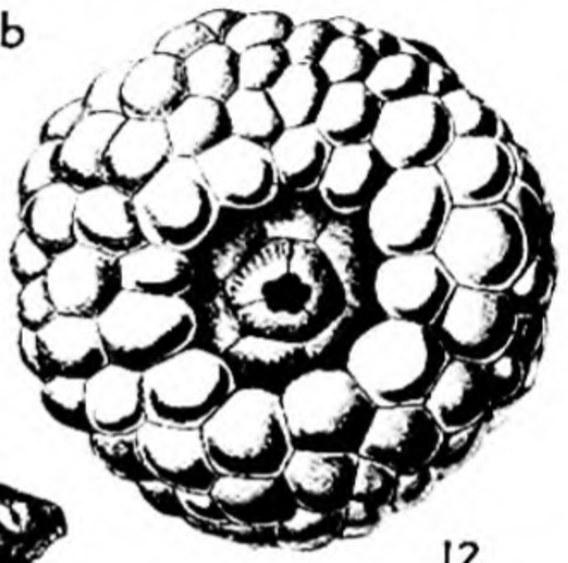
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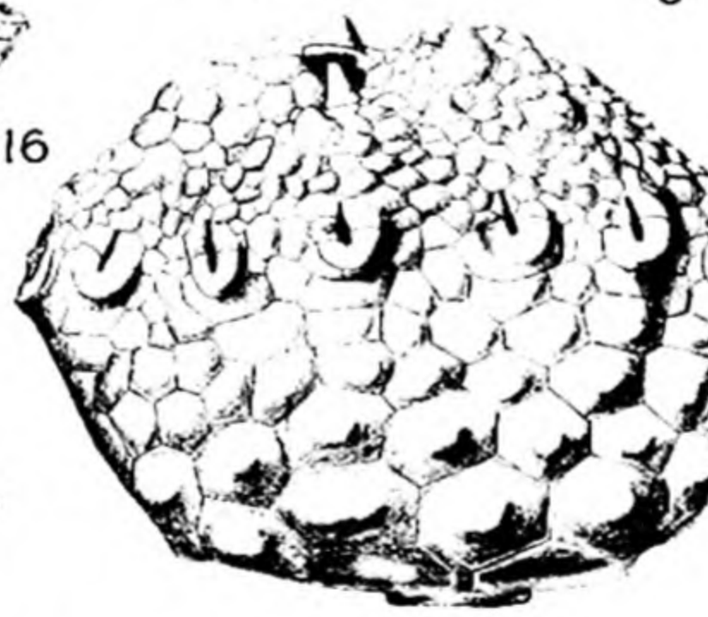
17a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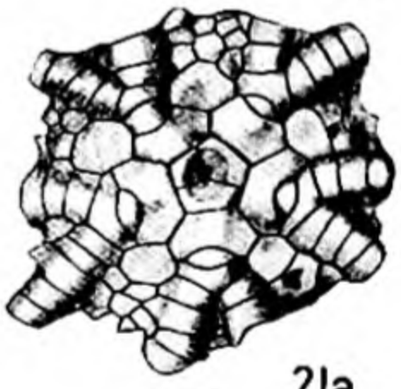
13a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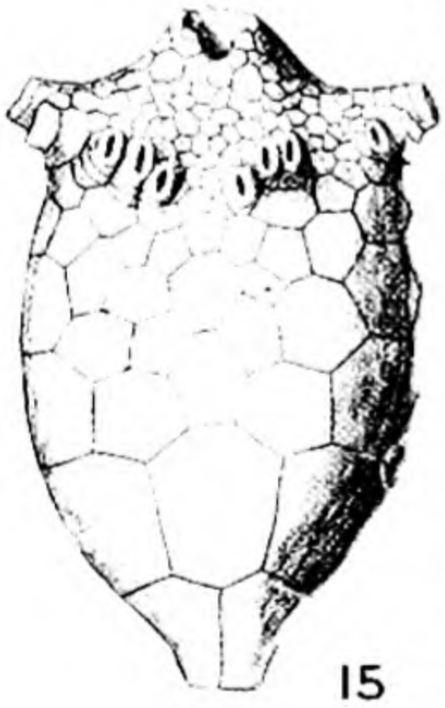
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17c

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21b

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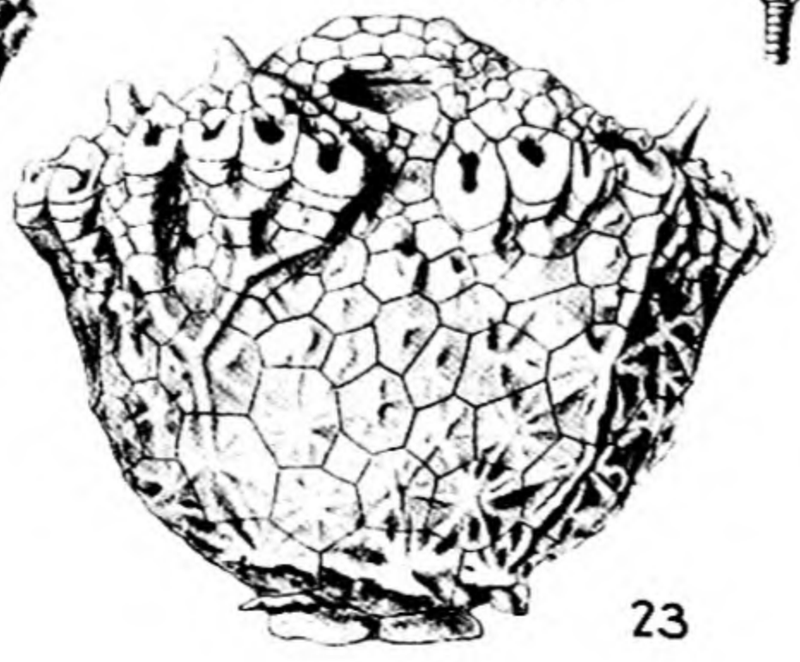
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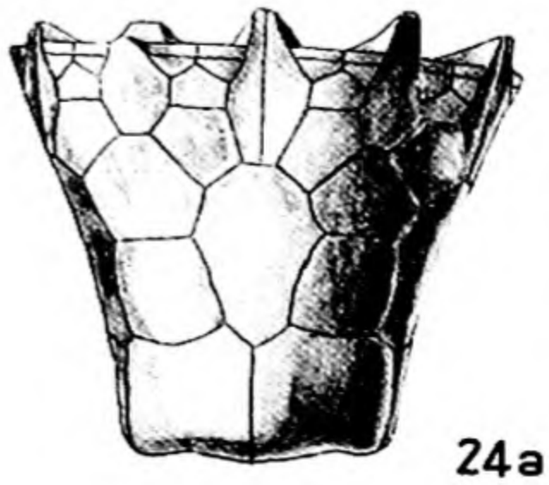
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24b

C. glans (Hall) [77—10]. A smooth-plated form; the youngest known species. **Burlington:** Ia., Mo.

TELEIOCRINUS

Wachsmuth and Springer 1881 [71—13]

(**Actinocrinus umbrosus* Hall). Like *Cactocrinus* but having a more steeply conical cup, many more arms and more numerous BrBr incorporated in calyx, producing a flaring wheel-shaped rim; arms directed outward instead of upward anal tube normally spinose (163). **Miss.** (Osage).

***T. umbrosus** (Hall) [77—1] (163). **Burlington:** Ia., Mo.

T. rudis (Hall) [77—11] (163). **Burlington:** Ia., Mo.

ACTINOCRINITES Miller 1821 [71—10]

(**A. triacontadactylus*). Cup conical, deeply lobed at arm bases; IBrBr widely connected with IAmbAmb and depressed at arm levels; anus at end of tube; arms biserial (163). **Miss.** (Kinderhook, Osage).

A. spinulosus (Miller and Gurley) [77—13]. Calyx small; tegmen spinose (17). **Chouteau:** Mo.

A. boonensis (Peck and Keyte) [77—12]. Cup small, plates less rugose than in *A. spinulosus*; tegminal plates relatively smooth (17). **Chouteau:** Mo.

A. ruber (Weller) [76—2]. Cup low, rapidly expanding (175). **Miss.:** Mo. (Fern Glen), N. Mex. (Lake Valley).

A. verrucosus (Hall) [76—1]. Cup high, widely flaring, lobate at arm bases (163). **Burlington:** Ia., Mo.

A. multiradiatus (Shumard) [76—3]. Small, distinguished by shape of cup and plate markings (163). **Burlington:** Ill., Ia., Mo.

A. tenuisculptus (McChesney) [77—14]. Small; cup expanding widely (163). **Lake Valley:** N. Mex.

A. lowei (Hall) [76—4]. Largest known form; plates very rugose (163). **Keokuk:** Ia., Mo.

STEGANOCRINUS

Meek and Worthen 1866 [71—12]

(**Actinocrinus pentagonus* Hall). Structure of dorsal cup as in *Actinocrinites*; arms produced into tubelike extensions that rise to the full height of the crown, branches given off from extensions on alternate sides; PBr_2 normally enters into the basal portion of the arm extension (163). **Miss.** (Kinderhook, Osage).

***S. pentagonus** (Hall) [77—6]. Cup low, flaring widely (163). **Burlington:** Ia., Mo.; **Lake Valley:** N. Mex.

S. sculptus (Hall) [77—5]. Cup higher and more strongly sculptured than in *S. pentagonus* (163). **Burlington:** Ia., Mo.

PHYSETOCRINUS

Meek and Worthen 1869 [71—15]

(**Actinocrinus ventricosus* Hall). Cup conical, widest at arm bases; arms grouped: IBrBr in contact with IAmbAmb; all BrBr above PBrBr axillary; tegmen composed of very small plates; IAmb areas depressed; anus opens directly through tegmen (163). **Miss.** (Osage).

***P. ventricosus** (Hall) [77—7]. Plates very strongly stellate; IAmb areas not markedly depressed (163). **Burlington:** Ia., Mo.

P. lobatus Wachsmuth and Springer [77—8]. IAmbAmb deeply depressed (163). **Lake Valley:** N. Mex.

STROTOCRINUS

Meek and Worthen 1866 [71—14]

(**Actinocrinus regalis* Hall). Characterized by the multiple branching of the BrBr within the cup, producing a widely flaring rim; tegmen composed of very small plates; anus opens directly through tegmen; plates highly stellate (163). **Miss.** (Osage).

S. glyptus (Hall) [77—9] (163). **Burlington:** Ia., Mo.

DESMIDOCRINIDAE. Monocyclic; BB three, equal; RR in contact except at anal side; PBr_1 quadrangular; X followed by three plates in next circlet; arms grouped; anus opens directly through tegmen. **Sil.–Miss.**

CARPOCRINUS Müller 1840 [71—4]

(**Actinocrinites simplex* Phillips). Calyx subglobular; IBrBr few; XX few, not in median ridges; arms uniserial, grouped (142). **Sil.** (Niagaran).

C. laurelianus (Springer) [75—13] (142). **Laurel:** Ind.

CYLICOCRINUS S. A. Miller 1892

(**C. canaliculatus*). Cup truncate conical; BB three; RR five; X in line with RR; PBrBr two, SBrBr two; IBrBr feebly developed; distinguished from *Carpocrinus* by its flaring base (142). **Sil.** (Niagaran).

***C. canaliculatus** S. A. Miller [75—16] (142). **Laurel:** Ind.

PLATE 75

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1a, b. Batocrinus icosadactylus (163). Dorsal, lat. **2, 3. Dizygocrinus** spp. **2a, b. D. rotundus** (163). Lat., ventral. **3. D. indianaensis** (163). **Post. 4a, b. Alloprosallocrinus conicus** (163). Dorsal, ant. **5–7. Batocrinus** spp. **5a, b. B. subaequalis** (163). Lat., post. **6. B. wachsmuthi** (163). **Lat. 7. B. macbridei** (163). **Lat. 8. Eutrochocrinus christyi** (163). **Post. 9–12. Megistocrinus** spp. **9. M. nobilis** (163). **Post. 10. M. nodosus** (163). **Lat. 11. M. evansii** (163). **Ant. 12. M. concavus** (163). Dorsal. **13a, b. Carpocrinus laurelianus** (142). Ant., post. **14, 15, Perlechocrinites** spp. **14. P. whitei** (163). **Lat. 15. P. tennesseensis** (163). **Post. 16. Cylicocrinus canaliculatus** (142). **Post. 17a–c. Saccocrinus benedicti** (142). Right ant., post., left ant. **18a, b. Callicrinus beachleri** (142). Dorsal, lat. **19, 20. Compsocrinus** spp. **19. C. miamiensis** (163). **Ant. 20. C. harrisi** (163). **Post. 21a, b. Comanthocrinus indianensis** (133). Dorsal, post. **22, 23. Gennaeocrinus** spp. **22. G. eucharis** (25). **Lat. 23. G. carinatus** (25). **Post. 24a, b. Eucalyptocrinites crassus** (163). Lat. of cup; lat. of crown showing arms in tegminal compartments.

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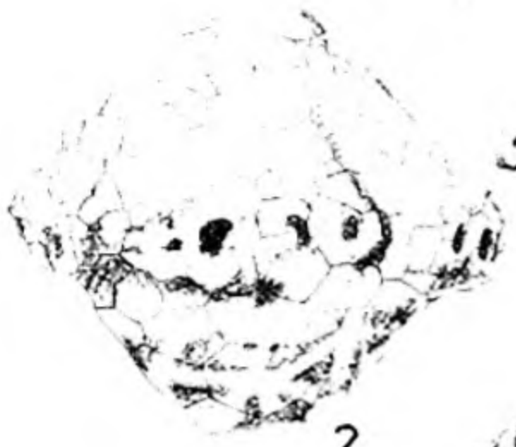
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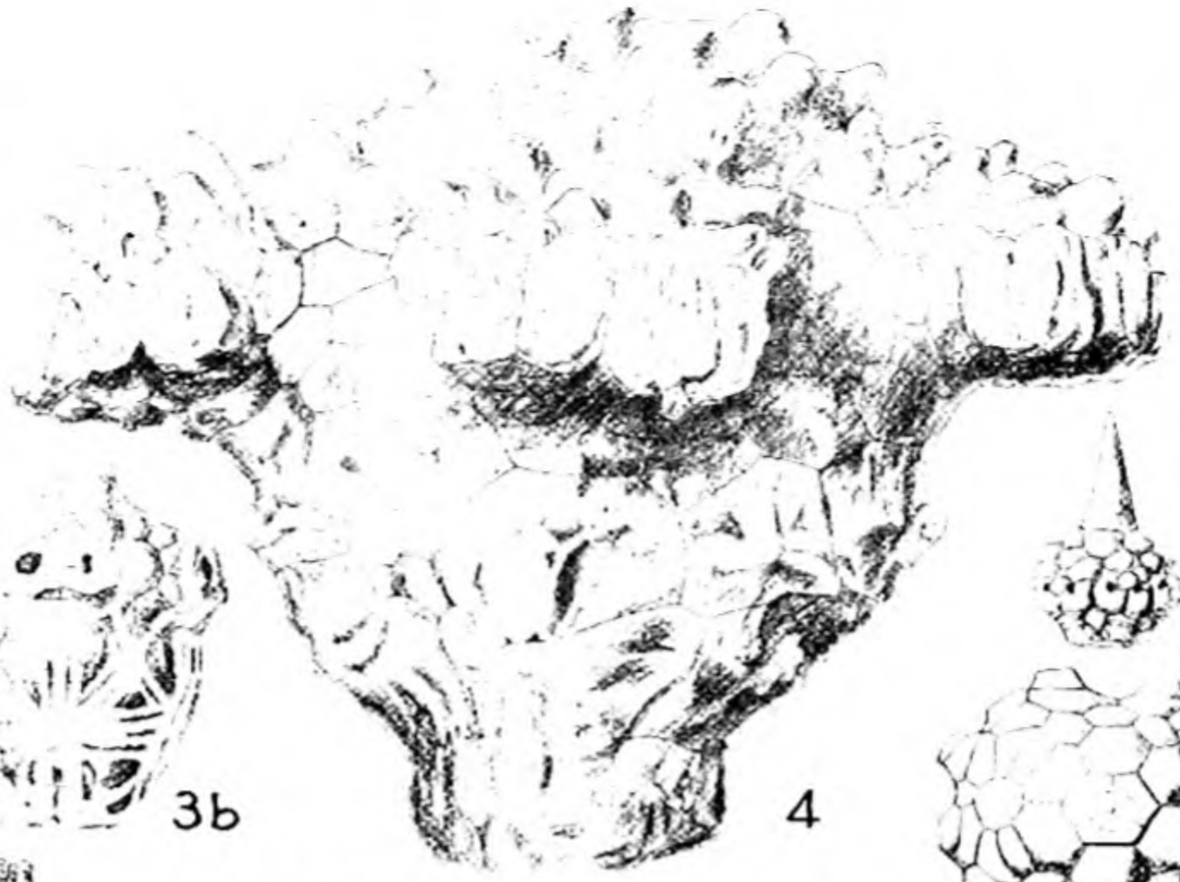
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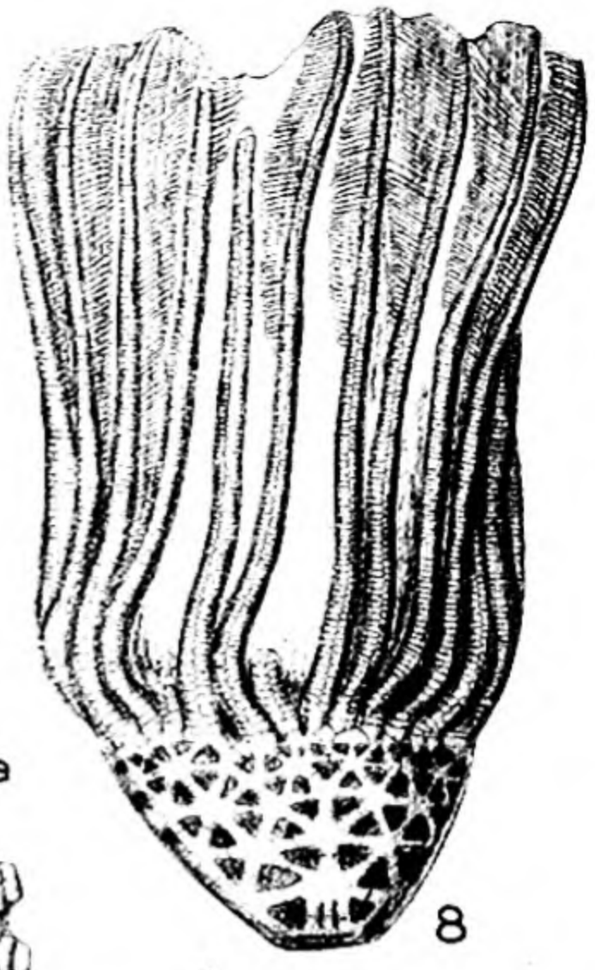
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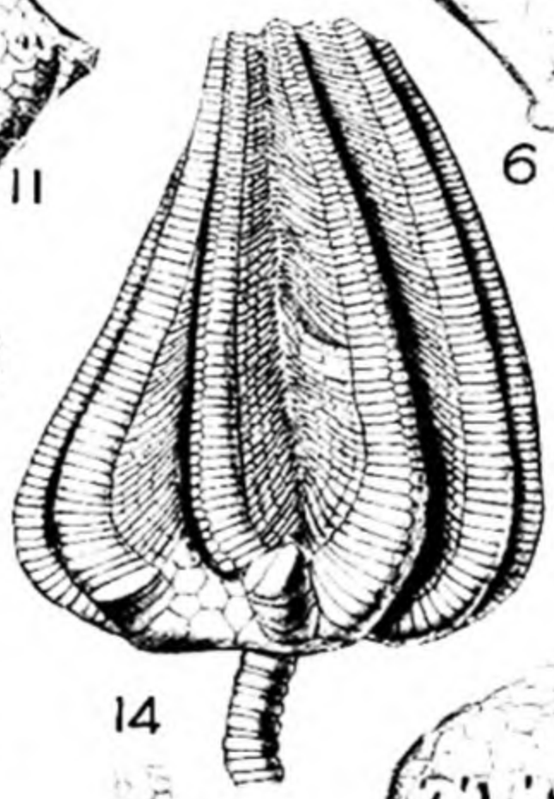
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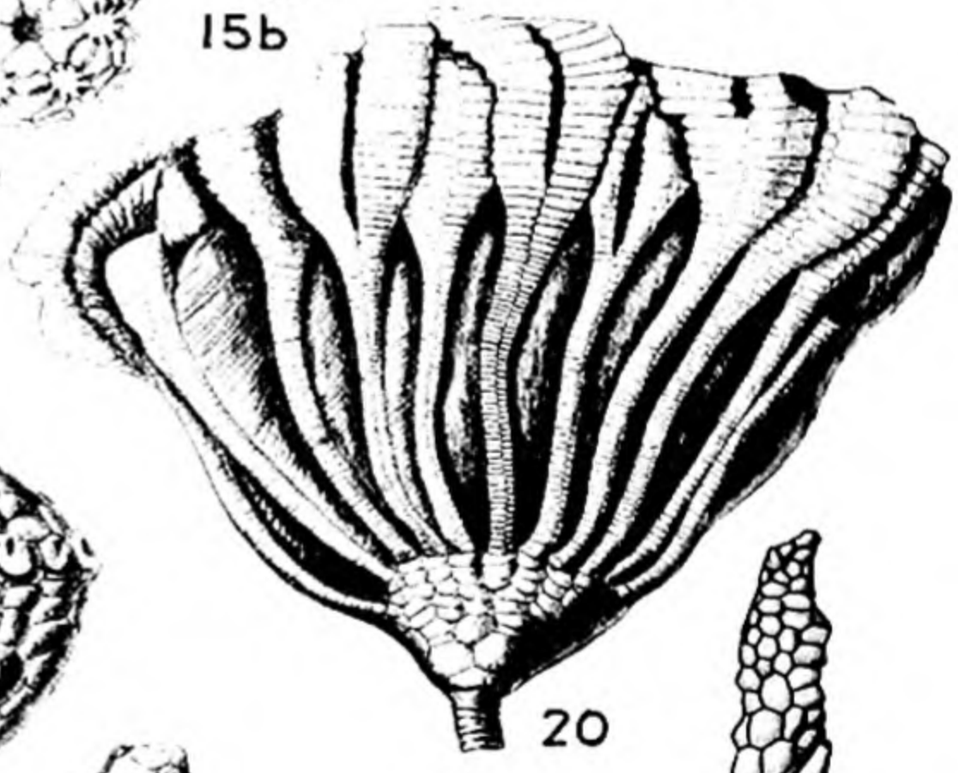
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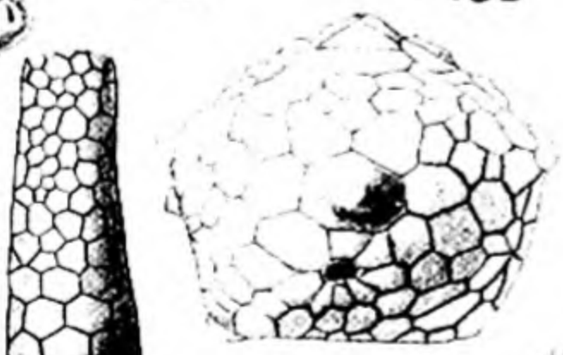
13b

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25

AOROCRINUS

Wachsmuth and Springer 1897

(**Dorycrinus immaturus*). Cup conical, summit lobed, IBrBr widely connected with IAmbAmb; arms grouped, not branching; anus opens directly through tegmen (163). **Sil.–Miss.**

A. armatus Goldring [**76**—10]. Low calyx; arms bearing laterally directed spines (25). **Dev.:** N. Y. (Hamilton).

***A. immaturus** (W and S) [**76**—9] (78). **Miss.:** Ia. (Hampton).

A. parvus (Shumard) [**76**—11] (163). **Miss.** (Burlington): Ia., Mo.

DORYCRINUS Roemer 1854 [71—9]

(**D. mississippiensis*). Cup conical, base lobed, generally expanded; IBrBr widely connected with IAmbAmb; anus opens directly through tegmen, which bears one or more large spines; arms grouped (163). **Miss.** (Osage).

D. unicornis (Owen and Shumard) [**76**—5]. Single spine on tegmen (163). **Burlington:** Ia., Mo.

D. missouriensis (Shumard) [**76**—7]. BB greatly expanded; six long spines on tegmen (163). **Burlington:** Ill., Ia., Mo.

***D. mississippiensis** Roemer [**76**—6]. Largest, latest, and most specialized known form of *Dorycrinus* (163). **Keokuk:** Ind., Ia., Mo.

AGARICOCRINITES Troost 1858 [71—8]

(**Amphoracrinus americanus* Roemer). Base flattened or concave; IBrBr widely connected with IAmbAmb; tegmen not spinose, anal vent directly through tegmen; arms grouped, large, elliptical, laterally directed (37, 163). **Miss.** (Kinderhook, Osage).

A. brevis (Hall) [**76**—15]. Base slightly convex; plates stellate (163). **Burlington:** Ia., Mo.

A. planoconvexus (Hall) [**76**—13] (163). **Burlington:** Ia., Mo.

A. bullatus (Hall) [**76**—14] (163). **Burlington:** Ia., Mo.

A. wortheni (Hall) [**76**—22]. Calyx large (163). **Keokuk:** Ind., Ia., Mo.

BATOCRINIDAE. Monocyclic; BB three, equal; RR in contact except at anal side; PBr_1 quadrangular; X followed by three plates in next circlet; anus opens through tube. **Miss.**

BATOCRINUS Casseday 1854 [71—6]

(**B. icosadactylus*). As commonly defined, *Batocrinus* has a biturbinate calyx, IBrBr not connected with IAmbAmb, anus at end of a tube, respiratory pores 20; the widely flaring low dorsal cup and strongly arched spinose tegmen of the genotype of *Batocrinus* differ decidedly from other species (except *B. calvini* Rowley) that are referred to this genus. **Miss.** (Kinderhook, Osage).

B. macbridei Wachsmuth and Springer [**75**—7]. Smallest known species (78, 163). **Hampton:** Ia.

B. subaequalis (McChesney) [**75**—5]. Convexity of tegmen approximately equal to that of dorsal cup (163). **Burlington:** Ia., Mo.

B. wachsmuthi (White) [**75**—6]. Cup large, high, steeply conical (163). **Keokuk:** Ind., Ia., Mo.

***B. icosadactylus** Casseday [**75**—1]. Low, rapidly expanding cup, highly arched spinose tegmen (163). **Warsaw:** Ind.

ERETMOCRINUS Lyon and Casseday 1859

(**E. magnificus*). Like *Batocrinus* except for flaring paddle-shaped arms, eccentric anal tube, and tendency toward an expanded base (163). **Miss.** (Kinderhook, Osage).

E. tentor Laudon [**76**—12]. An early, primitive form showing slight expansion of arms (74). **Gilmore City:** Ia.

E. remibrachiatus (Hall) [**76**—20]. Cup low conical, plates smooth; distal part of arms widely expanded (163). **Burlington:** Ia., Mo.

ALLOPROSALLOCRINUS

Casseday and Lyon 1862

(**A. conicus*). Dorsal cup conical, almost flat; tegmen high, ending in long central anal tube; IBrBr not connected with IAmbAmb; respiratory pores 20; distinguished from *Batocrinus* by shape of calyx (163). **Miss.** (Osage).

***A. conicus** (C and L) [**75**—4]. Only known species (163). **Keokuk:** Ind., Ia., Mo.

UPEROCRINUS Meek and Worthen 1865

(**Actinocrinus pyriformis* Shumard). IBrBr in contact with IAmbAmb; arms 20, grouped; anus at end of long central tube; respiratory pores not visible (163). **Miss.** (Osage).

***U. pyriformis** (Shumard) [**76**—24]. Cup elongate, lower sides subvertical; IBrBr weakly connected with IAmbAmb (163). **Miss.:** Ia. (Burlington), Mo. (Fern Glen, Burlington), Ark., Okla. (St. Joe), N. Mex. (Lake Valley).

U. nashvillae (Troost) [**76**—25]. Large spinose

PLATE 76

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1–4. Actinocrinites spp. 1. A. verrucosus (163). Post. **2. A. ruber** (175). Lat. **3a, b. A. multiradiatus** (163). Post., lat. **4. A. lowei** (163). Lat. **5–7. Dorycrinus spp. 5a, b. D. unicornis** (163). Lat., dorsal. **6. D. mississippiensis** (163). Post. **7. D. missouriensis** (163). Post. **8. Cactocrinus imperator** (74). Ant. **9–11. Aorocrinus spp. 9. A. immaturus** (163). Post. **10. A. armatus** (25). Lat. **11. A. parvus** (163). Post. **12a, b. Eretmocrinus tentor** (74). Ant., lat. **13–15. Agaricocrinites spp. 13a, b. A. planoconvexus** (163). Lat., ventral. **14. A. bullatus** (163). Lat. **15a, b. A. brevis** (163). Dorsal, post. **16. Uperocrinus aequibrachiatus** (163). Post. **17–19. Macrocrinus spp. 17a, b. M. koninckl** (163). Post., ant. **18a, b. M. jucundus** (163). Ant. views. **19a, b. M. verneuilianus** (163). Ant., post. **20. Eretmocrinus remibrachiatus** (163). Lat. **21. Eutrochocrinus christyi** (163). Lat. **22. Agaricocrinites wortheni** (163). Ant. **23–25. Uperocrinus spp.** (163). **23. U. longirostris.** Ant. **24. U. pyriformis.** Post. **25. U. nashvillae** (x0.5). Lat.

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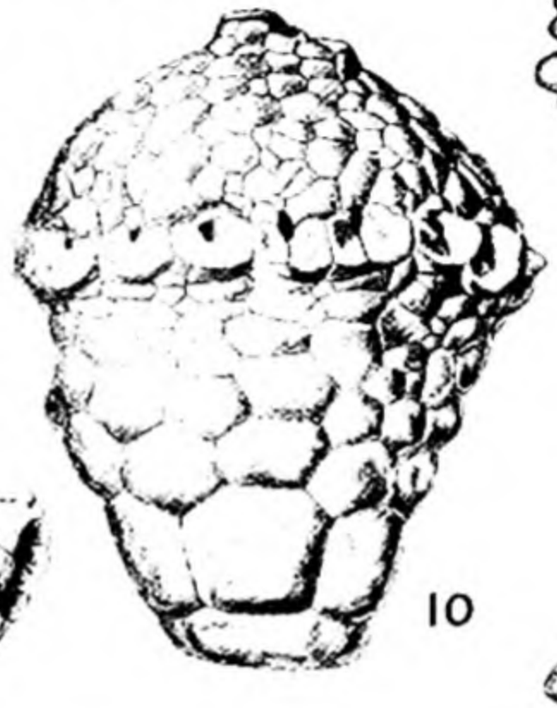
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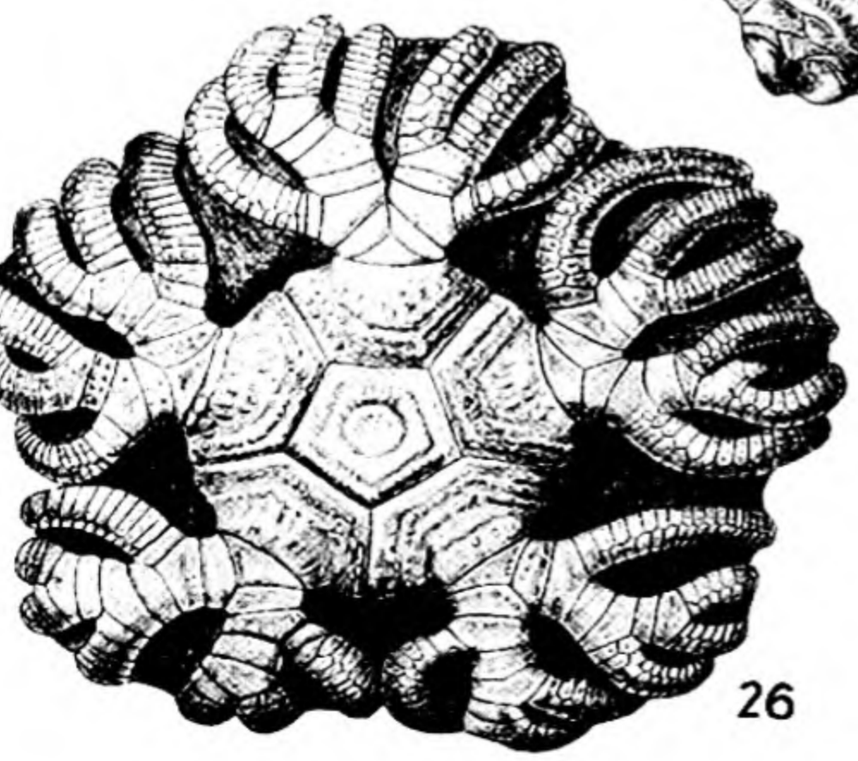
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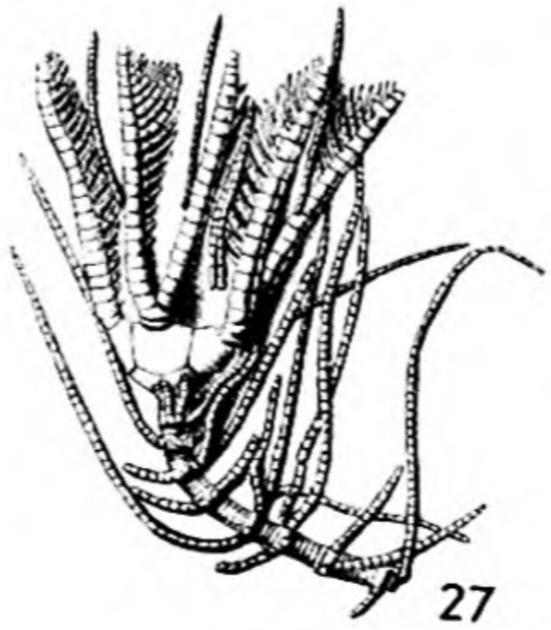
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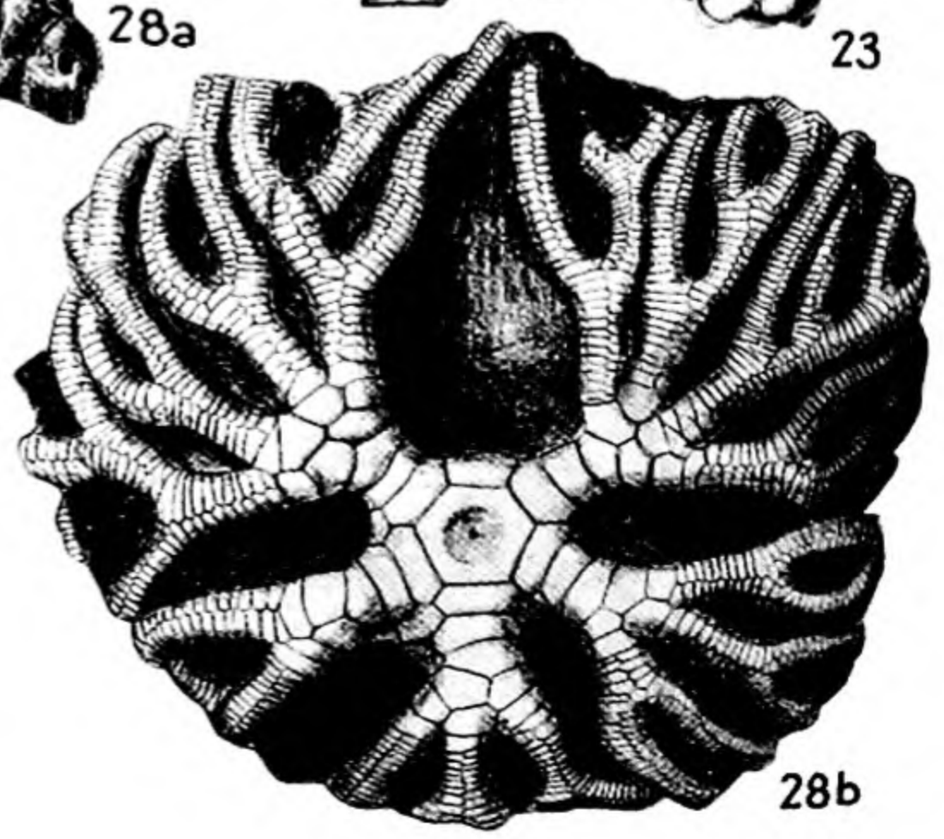

28b

form; structurally like *U. pyriformis* but lower part of cup less constricted (163). **Keokuk:** Ind., Ia., Mo.

U. aequibrachiatus (McChesney) [**76**—16]. Cup bell-shaped, abruptly widened at height of arm attachment; IBrBr strongly connected with IAmb-Amb (163). **Burlington:** Ia., Mo.

U. longirostris (Hall) [**76**—23]. Calyx shape like that of *Batocrinus*; IBrBr distinctly connected with IAmbAmb (163). **Burlington:** Ill., Ia., Mo.

MACROCRINUS

Wachsmuth and Springer 1897

(**Actinocrinus koninckii* Shumard). Small crinoids having an elongate biturbinate calyx; IBrBr in contact with IAmbAmb; respiratory pores 10; arms 12 to 16 (163). **Miss.** (Osage).

M. verneuilianus (Shumard) [**76**—19]. Slightly flaring rim **Burlington:** Ill., Ia., Mo.

***M. koninckii** (Shumard) [**76**—17]. Cup high and narrow, short spines on lower plates (163). **Burlington:** Ill., Ia., Mo.

M. jucundus (Miller and Gurley) [**76**—18]. Lower part of cup somewhat expanded (163). **Keokuk:** Ind.

EUTROCHOCRINUS

Wachsmuth and Springer 1897 [**71**—7]

(**Actinocrinus christyi* Shumard). Calyx expanded at arm bases, wheel-shaped in transverse outline; anus at end of tube; IBrBr in contact with IAmbAmb only at anal side (except in variant specimens); respiratory pores 20; arms short; easily recognized on basis of calyx shape alone (163). **Miss.** (Osage).

***E. christyi** (Shumard) [**75**—8, **76**—21]. Includes several varieties (163). **Miss.:** Ia., Mo. and Ill. (Burlington); Mo. and Ark. (Fern Glen); Ark. and Okla. (St. Joe); N. Mex. (Lake Valley)

DIZYGOCRINUS

Wachsmuth and Springer 1897

(**Actinocrinus indianaensis* Lyon and Casseday). Calyx globular; IBrBr in contact with IAmbAmb only at anal side; anal tube long, slender; respiratory pores not visible; arms 12 to 20; easily separable from *Eutrochocrinus* on calyx shape alone (163). **Miss.** (Osage).

D. rotundus (Yandell and Shumard) [**75**—2]. Round, smooth calyx; arms 20 (163). **Burlington:** Ia., Mo.

***D. indianaensis** L and C [**75**—3]. Calyx not rotund; rays marked by a median ridge (163). **Keokuk:** Ind., Ia., Mo.

HEXACRINITIDAE. Monocyclic; BB three, forming a hexagon; RR five, large, as in *Platycrinites* upper surfaces constricted at base of arms; X in line with RR; anus opens directly through tegmen. **Dev.**

HEXACRINITES

T. Austin and T. Austin, Jr. 1843

(**Platycrinites interscapularis* Phillips). BB three; RR five; X in line with RR; PBrBr one or two, arms uniserial, main branches bearing weaker lateral branches (163). **Dev.**

H. occidentalis (Wachsmuth and Springer) [**78**—8] (163). **Cedar Valley:** Ia.

ARTHROACANTHA Williams 1883

(**A. ithacensis*). BB three, unequal; RR five, large; X in line with RR; arms biserial, branching; plates of dorsal cup bear movable spines (25). **Dev.**

A. punctobrachiata Williams [**78**—9]. Cup conical, flaring, widest at arm bases (25). **Hamilton:** Ont.; N. Y.

A. splendens (Goldring) [**78**—10]. Large, cup slightly constricted at arm bases (25). **Chemung:** N. Y.

DICHOCRINIDAE. Monocyclic; BB two, forming a hexagon; RR five, large, in contact except at anal side; arms arise directly from upper edges of RR; anus opens directly through tegmen. **Miss.–Perm.**

DICHOCRINUS Münster 1839 [**71**—17]

(**D. radiatus*). Dorsal cup steeply conical; X large, almost equal in size to RR; arms uniserial or biserial; tegmen low, consisting of small plates; anus opens directly through tegmen (163). **Miss.** (Kinderhook–Chester).

D. delicatus Wachsmuth and Springer [**78**—2]. Cup small, high, narrow; plates smooth (78). **Hampton:** Ia.

D. inornatus Wachsmuth and Springer [**78**—7]. Like *D. delicatus* but larger (78). **Hampton:** Ia.

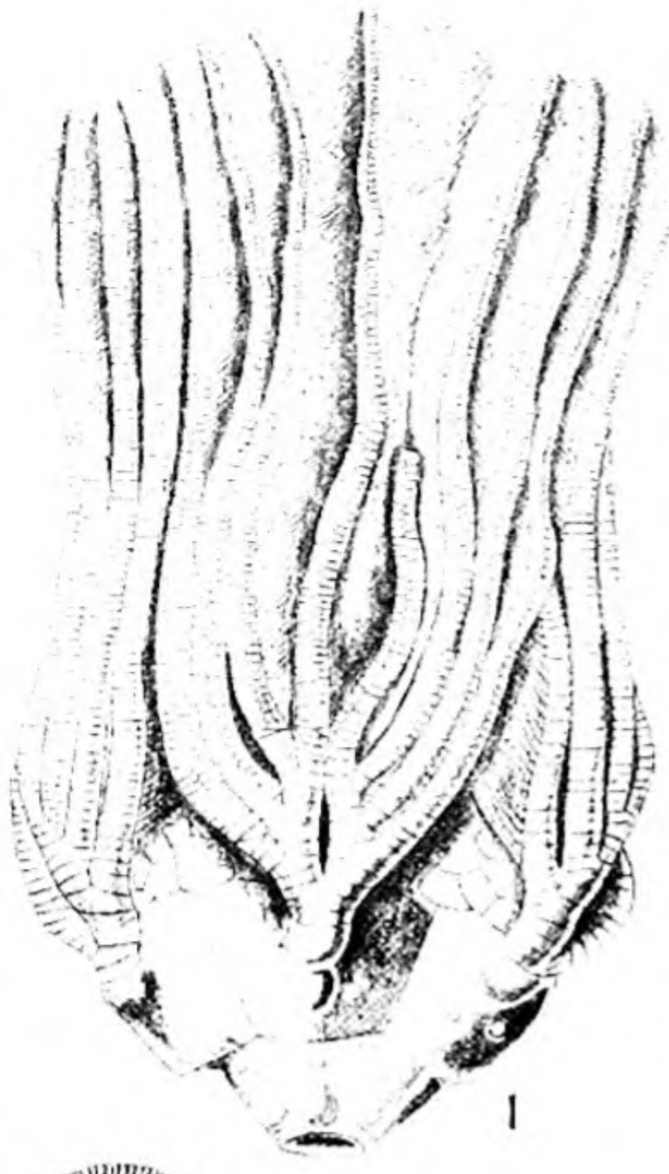
D. striatus Owen and Shumard [**78**—3]. Cup low, bowl-shaped, surface striated (163). **Burlington:** Ia., Mo.

D. plicatus Hall [**78**—5]. Calyx low, plates coarsely ribbed (163). **Burlington:** Ia., Mo.

PLATE 77

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1. Teleiocrinus umbrosus (163). Ant. **2–4. Cactocrinus** spp. **2. C. multibrachiatus** (163). Ant. **3. C. proboscidialis** (163). Post. **4. C. arnoldi** (78). Right ant. **5, 6. Steganocrinus** spp. **5. S. sculptus** (163). Lat. **6a, b. S. pentagonus** (163). Post., ant. **7, 8. Physetocrinus** spp. **7. P. ventricosus** (163). Ant. **8. P. lobatus** (163). Lat. **9. Strotocrinus glyptus** (163). Post. **10. Cactocrinus glans** (163). Ant. **11. Teleiocrinus rudis** (163). Ant. **12–14. Actinocrinites** spp. **12. A. boonensis** (17). Post. **13. A. spinulosus** (17). Post. **14. A. tenuisculptus** (163). Post. **15. Hapalocrinus gracilis** (142). Lat. **16, 17. Platycrinites** spp. **16a, b. P. allophylus** (17). Post., ant. **17. P. americanus** (163). Post. **18a, b. Brahmacrinus elongatus** (142). Lat. views. **19. Lyonicrinus bacca** (142). Ant. **20. Culicocrinus spinosus** (142). Lat. **21. Hapalocrinus cirrifer** (142). Lat. **22. Cyttarocrinus eriensis** (25). Left post. **23. Nyctocrinus magnitubus** (142). Right post. **24, 25. Marsupiocrinus** spp. **24. M. striatissimus** (142). Dorsal. **25a, b. M. rosaeformis** (142). Ventral, dorsal. **26. Platycrinites discoideus** (163). Dorsal **27. Cordylocrinus plumosus** (25). Lat. **28a, b. Amphoracrinus divergens** (163). Dorsal, lat.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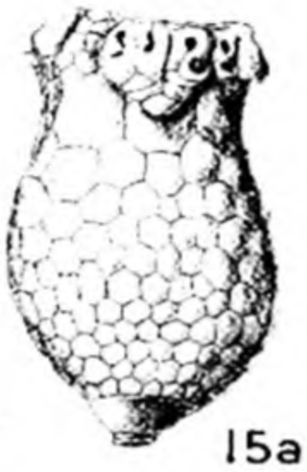
15a

15b

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14c

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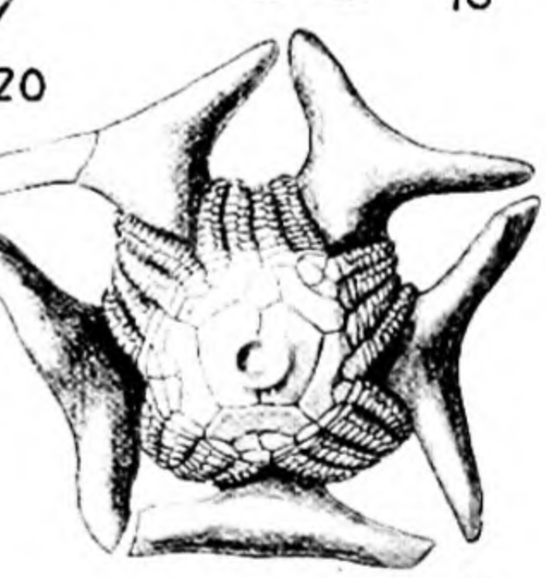
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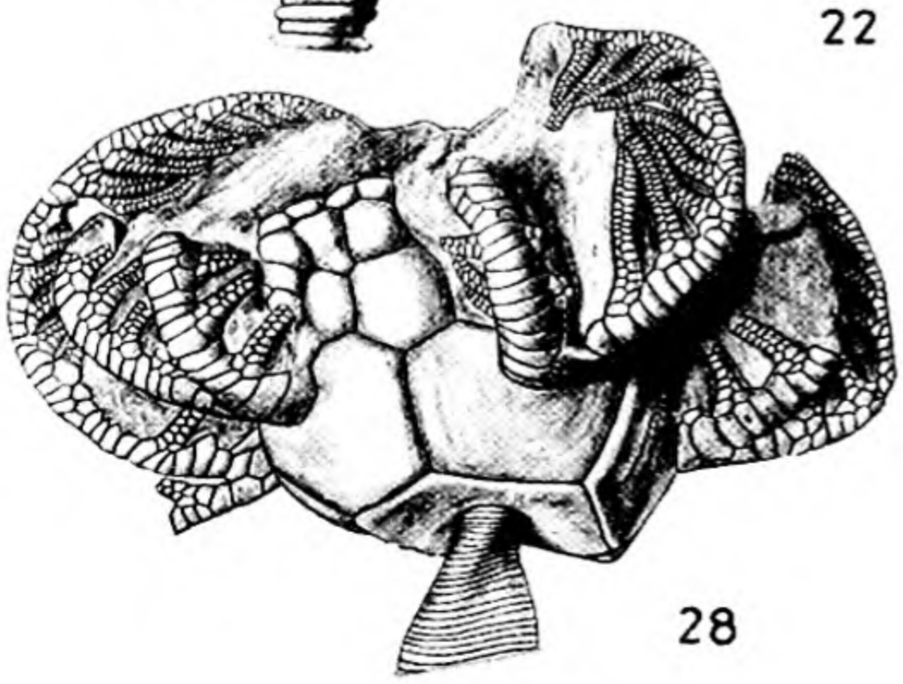
30a

30b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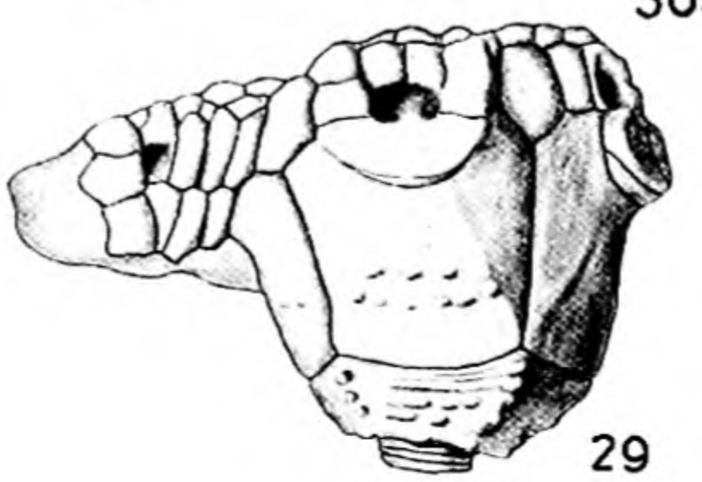
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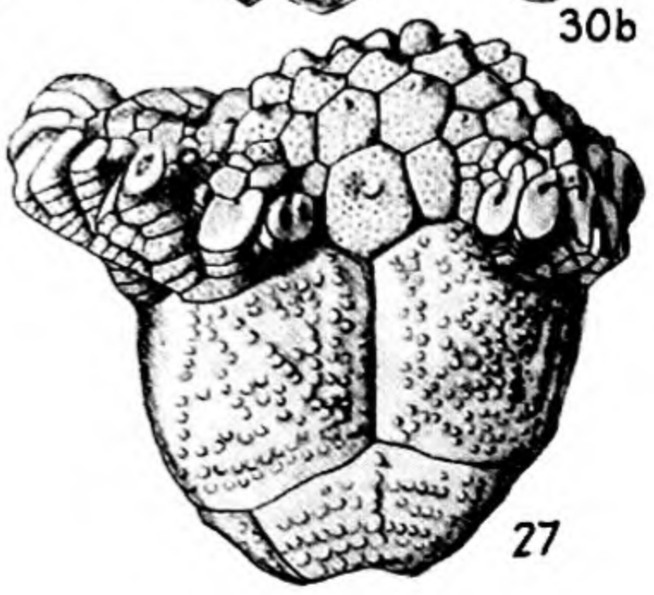
27

D. liratus Hall [78—4]. Similar to *D. plicatus* but having a much higher cup (163). **Burlington:** Ia., Mo.

PARADICHOCRINUS Springer 1926

(**Dichocrinus polydactylus* Lyon and Casseday). Like *Dichocrinus* but differs in having an inflated tegmen and endotomous arm structure (140). **Miss.** (Osage).

***P. polydactylus** (L and C) [78—1, 6]. Arms branching four times, making eight to the ray (140). **Keokuk:** Ind.

CAMPTOCRINUS Wachsmuth and Springer 1897

(**C. myelodactylus*). Differs from *Dichocrinus* in having coiled column that bears cirri on inner side of coil; normally the crown and proximal columnals are disproportionately small. **Miss.–Perm.**

C. multicirrus Springer [78—13] (140). **Miss.:** Ala. (Chester).

TALAROCRINUS Wachsmuth and Springer 1881

(**Dichocrinus cornigerus* Shumard). Plates of cup thick, outer surface convex, appearing inflated; PBr one, minute, triangular, often hidden from view; SBrBr overlapping PBr and resting obliquely against the R; TBr one; four arms in each ray; tegmen elevated, spinose; anal opening eccentric (140, 163). **Miss.** (Meramec, Chester).

T. ovatus Worthen [78—11] (140). **Miss.:** Ill.

***T. cornigerus** (Shumard) [78—12] (140). **Miss.:** Ala. (Ohara).

PTEROTOCRINUS Lyon and Casseday 1859

(**Asterocrinus capitalis* Lyon). Evolved from *Dichocrinus* through *Talarocrinus*; BB two, commonly nodose and inflated; X very small in comparison to RR, truncated on top so that RR are in contact above X; PBr one, small; SBr one, overlapping PBr and resting on R; TBr one, touching RR at its outer extremity; first radial tegmen plates extended into winglike spines (140). **Miss.** (Chester).

***P. capitalis** (Lyon) [78—16] (140). **Golconda:** Ky., Ill.

P. bifurcatus Wetherby [78—17] (140). **Glen Dean:** Ky.

ACROCRINIDAE. Characterized by addition of a large number of supplementary plates between BB and RR; evolved from *Dichocrinus*. **Miss., Penn.**

ACROCRINUS Yandell 1855

(**A. shumardi*). BB two; RR five; X in line with RR; BB and RR separated by a variable number of intercalated plates (intercalaries); arms as in *Dichocrinus* (140). **Miss., Penn.**

A. amphora Wachsmuth and Springer [78—15]. Large, representing maximum development of supplementary plates. **Miss.:** Ala. (Ohara).

A. pirum Moore and Plummer [78—14] (107). **Penn.:** Okla. (Morrow).

GLYPTOCRINIDAE. Monocyclic; RR in contact all around; median ray ridges present; IBrBr slightly depressed; anal area containing extra plates; median anal ridge absent; plates stellate. **Ord.**

GLYPTOCRINUS Hall 1847 [70—10]

(**G. decadactylus*). Dorsal cup high, conical, expanding regularly to arm bases; BB five, low, small; RR five, in contact all around; PBrBr two, SBrBr two, and TBrBr two in cup, median ridges on rays, ISBrBr and ITBrBr present; anal area marked by median row of plates; arms uniserial; plates stellate (163). **Ord.** (Mohawkian), **Sil.** (Niagaran).

G. dyeri Meek [73—23] (163). **Ord.:** Ohio (Maysville).

PERIGLYPTOCRINUS Wachsmuth and Springer 1897

(**P. billingsi*). Differentiated from *Glyptocrinus* on the basis of its larger BB and biserial arms (163). **Ord.** (Mohawkian).

***P. billingsi** W and S [73—25] (163). **Trenton:** Ont.

MELOCRINITIDAE. Monocyclic; RR in contact all around; IBrBr well defined; anal area not strongly differentiated, lacking a median row of plates; definitely evolved toward more perfect pentamerous symmetry. **Sil., Dev.**

ALISOCRINUS Kirk 1929

(**Mariacrinus warreni* Ringueberg). Cup high, conical, subpentagonal in cross-section; BB four; median ridge on rays, IBr areas slightly depressed; PBrBr two, SBrBr three, TBrBr two to seven in cup; tegmen low, flat; arms long, slender, uniserial, four to ray; probably ancestral to *Melocrinites* (57). **Sil.** (Niagaran).

A. laevis Kirk [74—2] (57). **Laurel:** Ind.

PLATE 78

[Figûres are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1. Paradichocrinus polydactylus (163). Lat. **2–5. Dichocrinus** spp. **2. D. delicatus** (163). Ant. **3a, b. D. striatus** (163). Lat., post. **4. D. liratus** (163). Post. **5. D. plicatus** (163). Lat. **6. Paradichocrinus polydactylus** (140). Post. **7. Dichocrinus inornatus** (163). Lat. **8. Hexacrinites occidentalis** (163). Ant. **9, 10. Arthroacantha** spp. **9. A. punctobrachiata** (25). Right post. **10. A. splendens** (25). Lat. **11, 12. Talarocrinus** spp. **11. T. ovatus** (163). Post. **12a, b. T. cornigerus** (163). Post., ventral. **13. Camptocrinus multicirrus** (140). Lat. **14, 15. Acrocrinus** spp. **14a–c. A. pirum** (107), type. Post., dorsal, ventral. **15a, b. A. amphora** (163). Right post. **16, 17. Pterotocrinus** spp. **16. P. capitalis** (163). Lat. **17. P. bifurcatus** (140). Dorsal. **18–27. Platycrinites** spp. **18. P. verrucosus** (163). Lat. **19. P. quinquenodus** (163). Post. **20. P. subspinulosus** (163). Lat. **21. P. hemisphericus** (163). Lat. **22. P. discoideus** (163). Post. **23. P. spinifer elongatus** (163). Lat. **24. P. burlingtonensis** (163). Lat. **25. P. sculptus** (163). Lat. **26. P. symmetricus** (163). Lat. **27. P. saffordi** (163). Post. **28–30. Euciadocrinus** spp. **28. E. pleurovimenus** (163). Post. **29. E. millebrachiatus** (163). Lat. **30a, b. E. tuberosus** (163). Dorsal, post.

CTENOCRINUS Bronn 1840 [70—12]

(*C. typus). Like *Melocrinites* but differs in arm structure, the two inner rami of arms strong, commonly in apposition, the outer pair still present, though in many species degenerated to feeble remnants (25, 57). **Sil., Dev.**

C. nobilissimus (Hall) [74—15]. A large form; crown expanding (25). **Dev.:** N. Y. (Coeymans).

C. pachydactylus (Conrad) [74—11, 14]. SBrBr three; arms uniserial (25). **Dev.:** N. Y. (Coeymans).

C. paucidactylus (Hall) [74—12]. SBrBr two; outer pair of arms strongly developed (25). **Dev.:** N. Y. (Coeymans).

MELOCRINITES Goldfuss 1826

(*M. hieroglyphicus). BB four; PBrBr two; arms extended into five tubelike appendages produced by union of the inside rami of the normal four-armed structure, outside rami absent (25, 163). **Dev.**

M. bainbridgensis (Hall and Whitfield) [74—9]. Plates lack sculpture (25). **Huron:** Ohio.

M. nodosus (Hall) [74—10]. Plates strongly nodose (163). **Dev.:** Mich. (Traverse), Wis., Ia. (Cedar Valley).

CYTOCRINUS Roemer 1860

(*C. laevis). A small primitive form having a steeply conical cup; BB three; PBrBr three, ending at arm openings, which are large and extended into tubelike projections; no SBrBr in cup (142). **Sil.** (Niagaran).

C. laevis Roemer [73—15] (142). **Beech River:** Tenn.

TECHNOCRINUS Hall 1857

(*T. andrewsi). Calyx structure somewhat resembles that of *Melocrinites*, but *Technocrinus* does not fall readily into the Melocrinitidae or any other recognized family; cup large, conical; BB four, flaring upward, making a definite portion of cup wall; PBrBr two, SBr one, TBrBr two, followed by stout, simple, biserial arms; XX lacking (25). **Sil., Dev.**

***T. andrewsi** Hall [74—8] (25). **Dev.:** Md. (Oriskany).

PATELLIOCRINIDAE. Monocyclic; BB three, unequal; RR in contact all around; anal side commonly having extra plates; PBrBr two, small, SBrBr normally one, followed by 10 arms; IBrBr few; differentiated from Melocrinitidae by simple structure of the calyx. **Sil.**

ALLOCRINUS

Wachsmuth and Springer 1889 [70—11]

(*A. typus). Cup low, broad, base flattened; BB three, unequal; one large IBr; XX absent; arms 10, uniserial, more than one pinnule to each Br (163). **Sil.** (Niagaran).

***A. typus** W and S [73—18]. Crown ovoid, BrBr of free arms inflated (142). **Beech River:** Tenn.

A. longidactylus Springer [73—21]. Plates of cup angular, nodose; arms long, slender (142). **Beech River:** Tenn.

PATELLIOCRINUS Angelin 1878

(*P. pachydactylus). Cup conical or bowl-shaped; BB three, unequal; SBrBr normally one, IBrBr few; XX absent; arms 10, biserial or cuneiform uniserial (142). **Sil.** (Niagaran).

P. ornatus Springer [73—16]. Cup conical, rapidly expanding; low ridges on BB and RR (142). **Laurel:** Ind.

P. rugosus Springer [73—22]. Cup bowl-shaped; rugose markings on plates (142). **Laurel:** Ind.

BRAHMACRINUS Sollas 1900

(*B. ponderosus). Cup high, steep-sided, base concave; BB three, equal; RR five, smaller than BB; PBrBr two, SBrBr two in dorsal cup, IBrBr definitely incorporated in cup (142). **Sil.** (Niagaran).

B. elongatus Springer [77—18] (142). **Laurel:** Ind.

MACROSTYLOCRINUS Hall 1852 [70—15]

(*M. ornatus). Cup conical; BB three, unequal; anal interradius wider than others, generally having three plates above X; arms 10, simple, biserial (163). **Sil.** (Niagaran).

***M. ornatus** Hall [74—13]. IBr areas depressed; arms unusually long (163). **Rochester:** N. Y.

M. fasciatus (Hall) [74—7]. Cup rounded, bowl-shaped; tegmen high (142). **Waldron:** Ind.

M. granulosus Hall [74—6]. Small; smooth-plated (142). **Waldron:** Ind.

M. striatus Hall [74—5]. Large plates; delicately striated (163). **Waldron:** Ind.

M. laevis Springer [74—4]. Widely expanding, smooth-plated (142). **Beech River:** Tenn.

CLONOCRINIDAE. Monocyclic; cup high, steeply conical, base deeply concave; BB three or four, at summit of concavity, not visible in side view of cup; RR five, laterally in contact, proximal parts in basal concavity; IBrBr few, in vertical series, IBr_1 large; XX absent. **Sil.** (Niagaran).

LAURELOCRINUS Springer 1926

(*L. paulensis). Sides of cup nearly vertical, base flattened; BB three, at summit of deep concavity; RR curving to form part of concavity and outer wall; PBrBr two, SBrBr two or three, IBr_1 very large (142). **Sil.** (Niagaran).

L. wilsoni Springer [73—19]. Cup high; tegmen constricted (142). **Laurel:** Ind.

***L. paulensis** Springer [73—20]. Cup not constricted at top (142). **Laurel:** Ind.

CLONOCRINUS Quenstedt 1876

(*Eucalyptocrinus polydactylus McCoy). Cup bowl-shaped; BB four, in basal concavity; RR large, forming part of basal concavity; PBrBr two, PBr_1 quadrangular, PBr_2 hexagonal; IBrBr large, a

single long ISBr in cup; differs from *Eucalyptocrinites* in that the arms are not in compartments and higher IBrBr are irregular (142). **Sil.** (Niagaran).

C. occidentalis Springer [**73**—13, 24] (142). **Decatur:** Tenn.

DOLATOCRINIDAE. Cup depressed, broader than high; BB three, unequal, small, commonly fused; PBrBr two, PBr_1 quadrangular; IBrBr few, IBr_1 very large; XX absent. **Dev.**

DOLATOCRINUS Lyon 1857 [**70**—16]

(**D. lacus*). Calyx depressed, subglobose; BB small, commonly fused; IBrBr large, IBr_1 exceptionally large; respiratory pores on tegmen; arms biserial, branching (163). **Dev.**

D. lyoni Miller and Gurley [**74**—17]. BB confined to basal concavity; plates stellate, highly nodose (163). **Helderberg:** Ind.

D. speciosus (Hall) [**74**—16]. Calyx large, low, relatively smooth; median ridge on rays, accented on RR (163). **Onondaga:** N. Y.

***D. lacus** Lyon [**74**—20]. Base flatly truncate, sides nearly straight (163). **Onondaga:** Ky.

D. marshi Lyon [**74**—22]. Tegmen high; median ridges on rays sharp, angular (163). **Onondaga:** Ky.

D. bellulus Miller and Gurley [**74**—21]. Distinguished by surface markings (163). **Hamilton:** Ind.

D. argutus Miller and Gurley [**74**—19]. Small, globular, relatively smooth-plated form (163). **Hamilton:** Ind.

D. bulbaceous Miller and Gurley [**74**—18]. Small, globular; median ridges on rays; plates nodose (163). **Hamilton:** Ind., Ky.

STEREOCRINUS Barris 1878 [**70**—18]

(**S. triangulatus*). Like *Dolatocrinus* except that each ray has one PBr instead of two and RR are correspondingly larger (163). **Dev.**

***S. triangulatus** Barris [**74**—23]. Surface markings make triangles (163). **Cedar Valley:** Ia.

S. helderbergensis Springer (133). **Linden:** Tenn.

CLARKEOCRINUS Goldring 1923 [**70**—7]

(**Cacabocrinus troosti* Hall). Cup small, bowl-shaped, structure as in *Dolatocrinus* but BB three, large, recurved; PBrBr two, SBr one, TBr one, followed by free arms; IBr_1 large, rising to full height of SBr, one small ISBr present; arms slender, uniserial, branching, four to the ray; long coiled cirri given off at intervals along column (163). **Dev.**

***C. troosti** (Hall) [**74**—1] (25). **Hamilton:** N. Y.

COMANTHOCRINUS Springer 1921

(**Stereocrinus indianensis* Miller and Gurley) Dorsal cup essentially flat, slightly depressed at center; BB three; RR five, large; PBrBr two, SBrBr three, followed by free arms; IBr_1 large, followed by two smaller plates; sharp median ridge on rays; tegmen highly arched; arms massive, uniserial (133). **Dev.**

***C. indianensis** (M and G) [**75**—21] (133). **Hamilton:** N. Y., Ind., Ky.

EUCALYPTOCRINITIDAE. Monocyclic; BB four, in deeply invaginated base of cup; structure above BB perfectly pentamerous; RR in contact all around, partly in basal concavity and recurved to form lower portion of lateral wall; arms resting in compartments formed by partitions resting on IBrBr and ITBrBr and attached to tegmen, which consists of four cycles of plates forming a long tube (163). **Sil.** (N. America; Europe), **Dev.** (Europe).

EUCALYPTOCRINITES Goldfuss 1826 [**71**—2]

(**E. rosaceus*). Partitions between arms rise to full height of arms; IBrBr and ITBrBr rise above the point of origin of the free arms. **Sil.** (N. America; Europe), **Dev.** (Europe).

E. crassus (Hall) [**75**—24]. Cup high, medium in size, plates smooth. **Niagaran:** Ind., Wis.; Ill., Ia.

CALLIOCRINUS Orbigny 1849

(**Eugeniacrinites costatus* Hisinger). Arm partitions incomplete, less than height of arms; plates unusually spinose and rugose (163). **Sil.** (Niagaran).

C. beachleri Wachsmuth and Springer [**75**—18]. Base pentagonal, flaring, sharp median ridge on rays; plates rugose (163). **Laurel:** Ind.

MARSUPIOCRINIDAE [**71**—16]. Monocyclic; base flattened to concave; BB three, unequal; RR in contact all around; PBr small, triangular; SBr_1 rests on both PBr and R; no X in cup; anus opens directly through tegmen; stem round. **Sil., Dev.**

MARSUPIOCRINUS Morris 1843 [**71**—16]

(**Marsupiocrinites coelatus* Phillips). Cup low, flattened, discoid, base flat; BB three, unequal; RR five, in plane with BB; PBr one, small, triangular; SBr one resting on both PBr and R; arms stout, biserial, laterally directed; anus opens directly through tegmen, subcentral; column round (142). **Sil., Dev.**

M. rosaeformis (Troost) [**77**—25] (142). **Sil.:** Tenn. (Beech River).

M. striatissimus (Springer) [**77**—24] (142). **Sil:** Tenn. (Beech River).

THALLOCRINIDAE. Monocyclic; BB three, unequal; RR large, in contact all around; PBrBr, IBrBr, and XX excluded from cup; tegminal plates few, mainly OO; column round. **Sil., Dev.**

LYONICRINUS Springer 1926

(**Coccocrinus bacca* Roemer). PBrBr two; tegmen composed of five triangular IAmbAmb, separated by open ambulacra; X and two small flanking plates lie in posterior IAmb area; arms 10, uniserial unbranched (142). **Sil.** (Niagaran).

***L. bacca** (Roemer) [**77**—19] (142). **Beech River:** Tenn.

1a
1b
1c
2
3c
3b
3a
4
5
6
7a
7b
8a
8b
9a
9b
10a-b
11a
11b
11c
11d
12a,b
13a,b
14a
14b
15a-c
16a-c
17a-c
18
19a
19b
20a
20b
21a
21b
21c
22a-c
23a-c
24a
24b
24c
25a
25b
25c
26a
26b
27a
27b
28
29a
29b
30
31
32
33a
33b
34a
34b

CULICOCRINUS Müller 1854

(**Platycrinus nodosus*). Like *Lyonicrinus* except the five triangular IAmbAmb plates are united by close suture and are preceded by other IAmbAmb; also open ambulacra are lacking; arms biserial, massive (142). **Sil.** (Niagaran).

C. spinosus Springer [77—20]. Questionably referred to *Culicocrinus* (142). **Beech River:** Tenn.

HAPALOCRINUS Jaekel 1895

(**H. elegans*). Cup low, base flat; RR essentially vertical; arms uniserial, strongly cuneiform, branching at least once, bearing stout pinnules; column round, carrying cirri throughout its length; OO small (142). **Sil., Dev.**

H. cirrifer Springer [77—21]. Arms long, slender (142). **Sil.:** Tenn. (Beech River).

H. gracilis Springer [77—15]. Arms robust, BrBr strongly cuneiform, pinnules large (142). **Sil.:** Tenn. (Beech River).

CORDYLOCRINUS Angelin 1878

(**C. comtus*). PBrBr two, followed by uniserial arms; X in notch between RPR and LPR; tegmen produced into long tube rising slightly higher than crown; column round, giving off cirri throughout its length (25). **Dev.** (Helderberg).

C. plumosus (Hall) [77—27] (25). **Coeymans:** N. Y.

CYTTAROCRINUS Goldring 1923

(**Platycrinus eriensis* Hall). Column round; arms uniserial; BrBr of arms very elongate (25). **Dev.** (Helderberg).

***C. eriensis** (Hall) [77—22] (25). **Coeymans:** N. Y.

PLATYCRINITIDAE. Monocyclic; BB three, unequal, forming a pentagon; RR large, in contact all around; no XX in cup; anus opens directly through tegmen; arms rise directly from upper edges of RR; column twisted. **Miss.–Perm.**

PLATYCRINITES Miller 1821 [71—18]

(**P. laevis*). BB three, large, unequal, forming a pentagon, may be partly or complete fused, small B in LA position; RR five, very large; the cup shape may be steeply conical, bowl-shaped, widely flaring, flat, or concave; arms attached to narrow facet at summit of RR; structure of the tegmen varies greatly, depending on shape of dorsal cup; anus opens directly through tegmen; no XX in cup (163). **Miss.–Perm.**

P. allophylus (S. A. Miller) [77—16]. A primitive type; cup steeply conical (17). **Miss.:** Mo. (Chouteau).

P. burlingtonensis (Owen and Shumard) [78—24]. Cup high, bowl-shaped, smooth (163). **Miss.** (Burlington): Ia., Mo.

P. symmetricus (Wachsmuth and Springer) [78—26]. Cup slightly lower than in *P. burlingtonensis* (78). **Miss.:** Ia. (Hampton).

P. quinquenodus (White) [78—19]. Sides of cup slanting, conical, plates smooth, tegmen inflated (163). **Miss.** (Burlington): Ia., Mo.

P. discoideus (Owen and Shumard) [77—26, 78—22]. BB and RR in flat plane; surface finely nodose (163). **Miss.** (Burlington): Ia., Mo.

P. americanus (Owen and Shumard) [77—17]. Base flat; RR vertical; plates smooth (163). **Miss.** (Burlington): Ia., Mo.

P. spinifer elongatus (Wachsmuth and Springer) [78—23]. Base nearly flat; RR vertical; plates smooth; tegmen inflated (163). **Miss.:** Ia. (Burlington).

P. verrucosus (White) [78—18]. Small; RR sloping outward; plates nodose (163). **Miss.** (Burlington): Ia., Mo.

P. sculptus (Hall) [78—25]. Cup high, nodose plate markings (163). **Miss.:** N. Mex. (Lake Valley).

P. subspinulosus (Hall) [78—20]. Similar to *P. verrucosus* but cup higher, flaring slightly more at arms, and plates having fewer, larger nodes (163). **Miss.:** Ia. (Burlington).

P. hemisphericus (Meek and Worthen) [78—21].

PLATE 79

[Figures are x1 unless otherwise indicated; source references indicated in parentheses immediately after species name.]

1, 2. Rhizocrinus spp. 1a–c. R. alabamensis (21). Side of basal cone; ventral; dorsal. **2. R. cylindricus** (21) (x2), type. Lat. **3a–c. Pentacrinus knighti** (126). Crown (type); calyx and lower brachials (x2); columnal (x2). **4, 5. Balanocrinus spp. 4. B. haitiensis** (138) (x2). Articular face of columnal. **5. B. mexicanus** (138) (x1.5). Articular face of columnal. **6. Pentacrinus asteriscus** (21) (x5), type. Articular surface of columnal. **7a, b. Apiocrinus tehuantepec** (138) (x1.5), type. Articular surface of columnal; side view of columnals. **8a, b. Pentacrinus subangularis alaska** (138) (x2), types. Articular surfaces of columnals. **9a, b. Columnal dispar** (102), type. Lat. and articular views of nodal columnal. **10a, b. Pentacrinus californicus** (21) (x6), type. Articular and lat. views of columnal. **11a–d. Brachial simus** (107). Proximal, lateral, and distal views of a typical specimen; distal view of a large specimen. **12a, b. Stereobrachicrinus pustullosus** (107). Lat. and external views. **13a, b. Columnal granulosus** (102), type. Articular and side views. **14a, b. Columnal excentricus** (102), type. Articular and side views. **15a–c. Facetal tuberculatus** (102), type. Side, facetal, and external views. **16a–c. Facetal corrugatus** (102), type. Side, facetal, and external views. **17a–c. Tegminal expansus** (102), type. Lower, side, and upper views. **18. Facetal lineatus** (102), type. External view (x2). **19a, b. Brachial acutus** (102), type. Lat. and distal views. **20a, b. Columnal spicatus** (102), type. Articular and lat. views. **21a–c. Apical urna** (102), type. Side, dorsal, ventral. **22a–c. Polygonal tenuirugosus** (102), type. External, side, proximal. **23a–c. Facetal canalis** (102), type. Lat., facetal, and external views. **24a–c. Apical glyptus** (102), type. Internal, external, and side views. **25a–c. Apical regularis** (102), type. Internal, external, and side views. **26a, b. Marsupites americanus** (21). Dorsal, lat. **27, 28. Edriocrinus spp. 27a, b. E. sacculus** (53). Adult showing attachment scar; cluster of attached young specimens. **28. E. pyriformis** (53). Side view showing cup and elongate base. **29a, b. Ageneracrinus subtumidus** (153), type. Dorsal, post. **30. Ancyrocrinus spinosus** (25). Lat. **31. Uintacrinus socialis** (3). View of somewhat flattened crown, interbrachial plates stippled. **32. Amphicrinus carbonarius** (76). Dorsal. **33a, b. Edriocrinus dispansus** (53), type. Lat., ventral. **34a, b. Camarocrinus ulrichi** (122). Lateral and proximal view of bulb.

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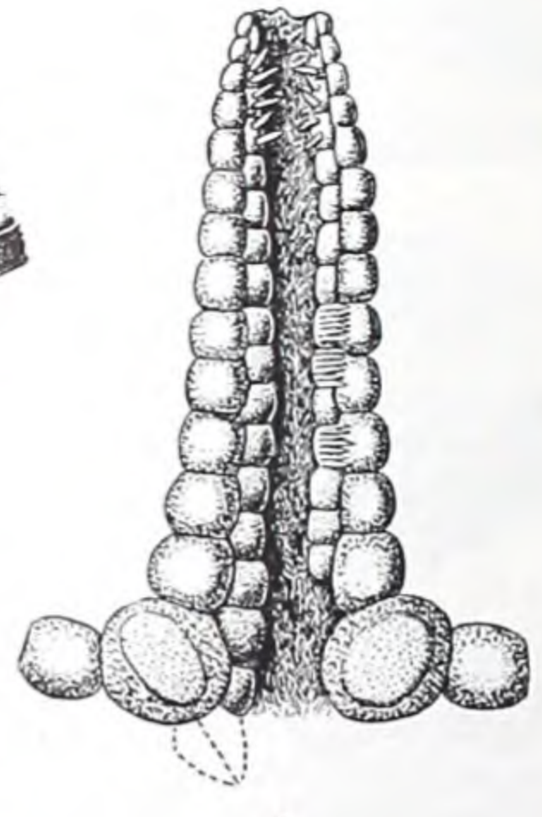

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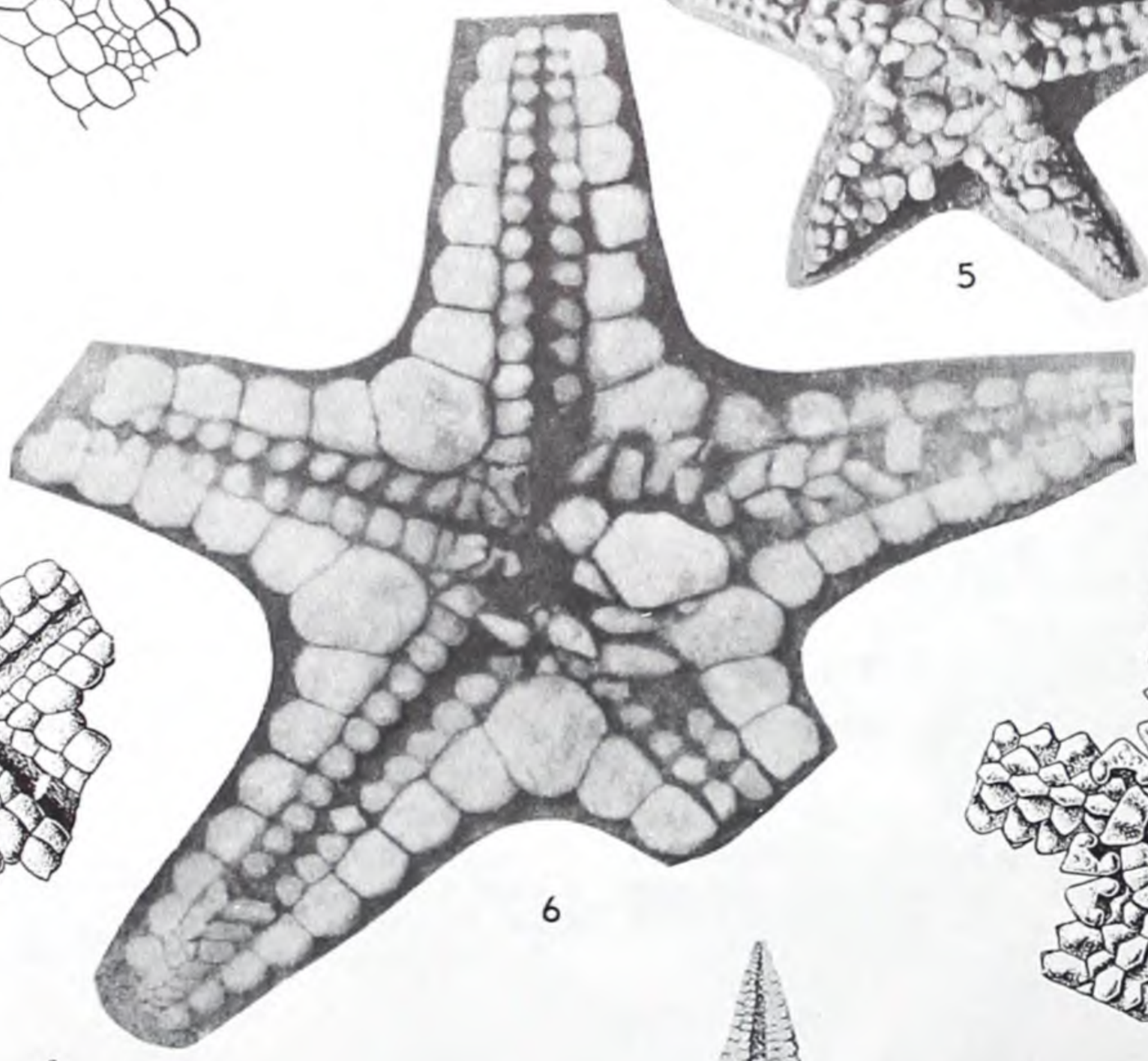

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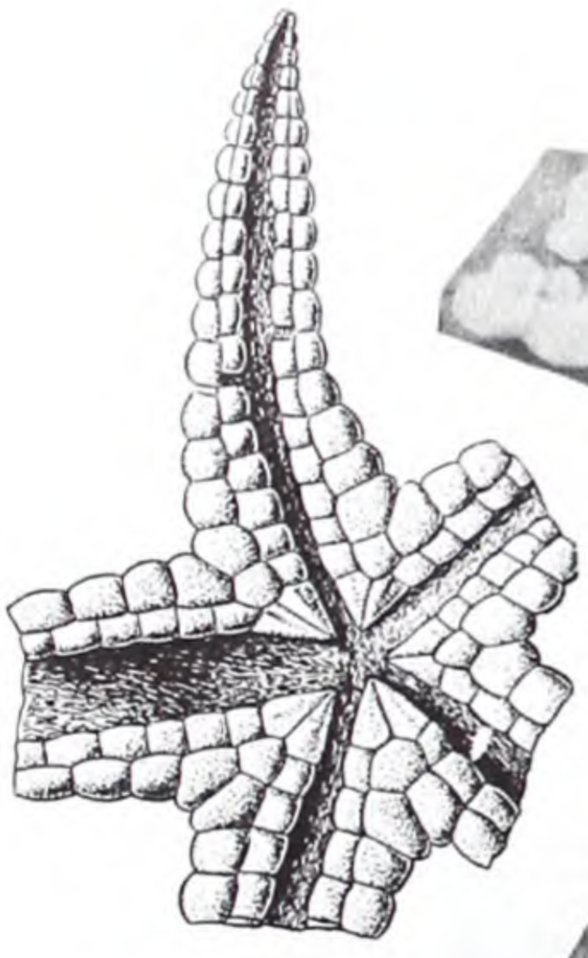

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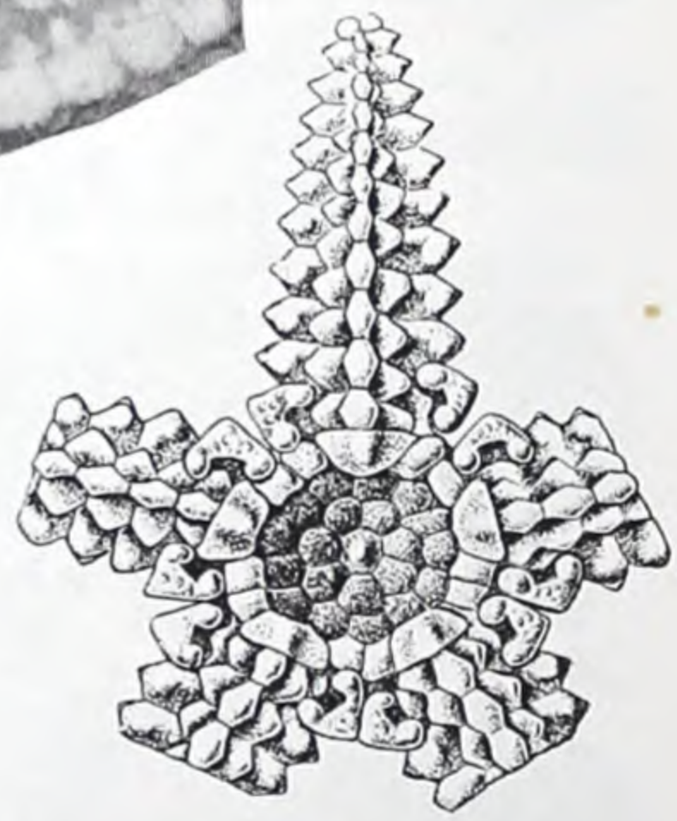

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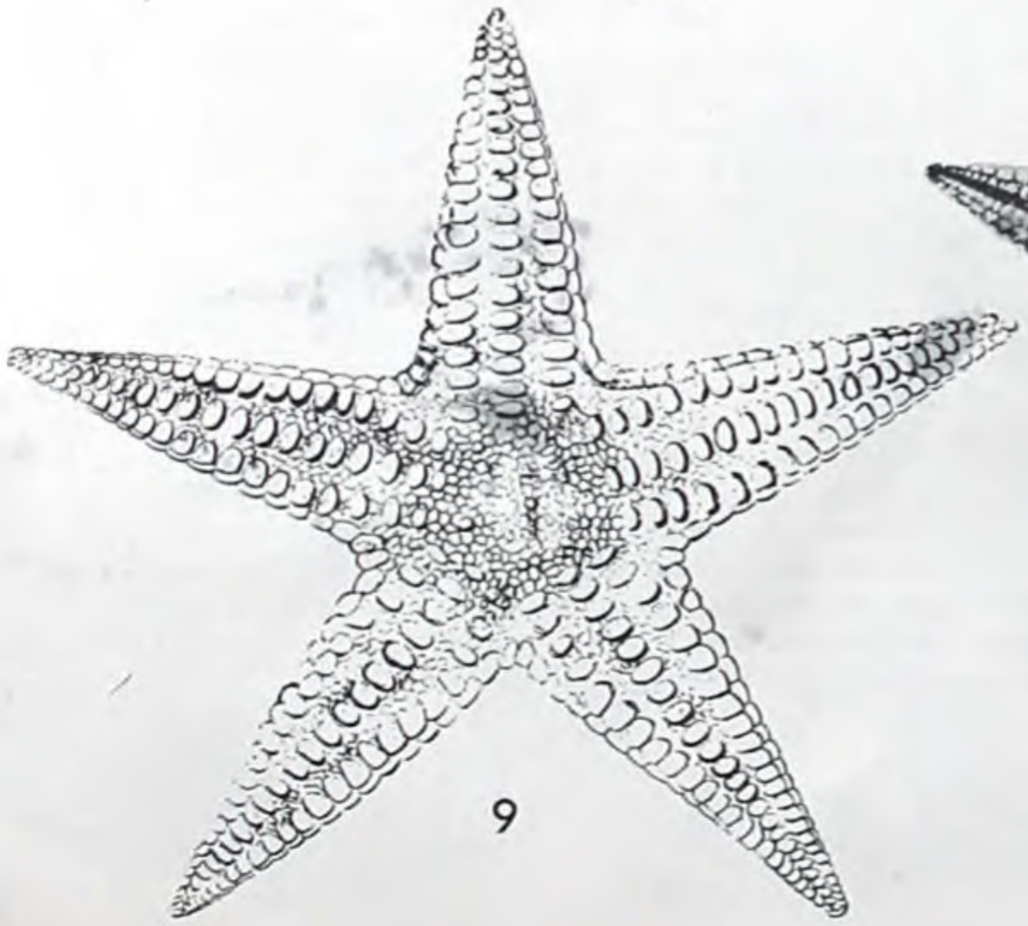

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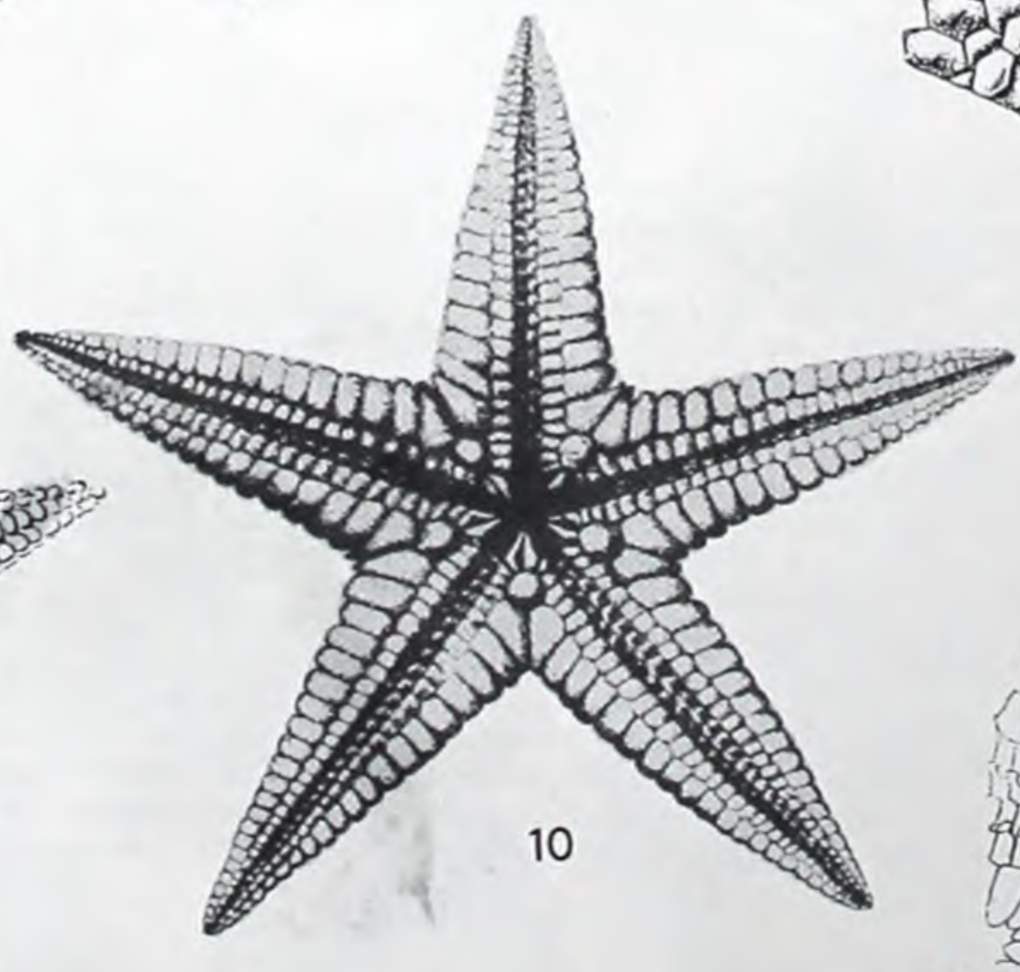

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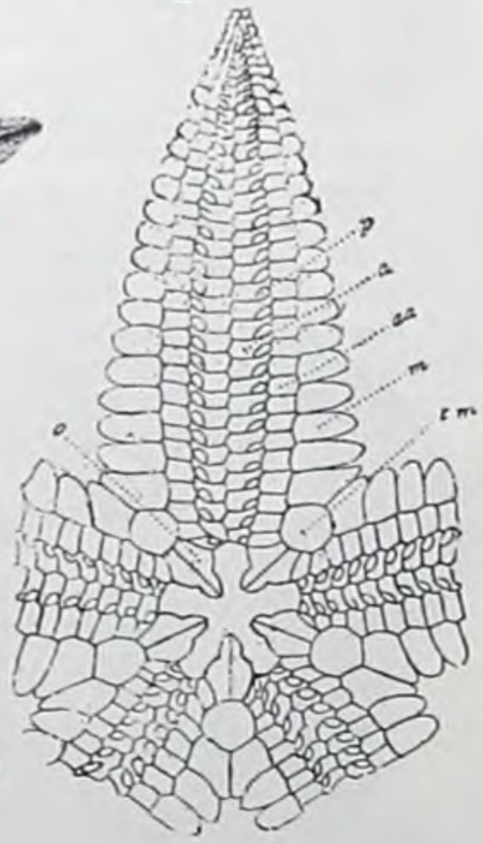

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Cup larger, walls more nearly vertical; plates nodose (163). **Miss.:** Ind. (Keokuk).

P. saffordi (Hall) [78—27]. Cup larger and higher than that of *P. hemisphericus*, sides nearly vertical; surface covered with smaller nodes (163). **Miss.:** Ind. (Keokuk).

EUCLADOCRINUS Meek 1871

(**E. montanensis*). Cup as in *Platycrinites*, rays develop into tubular extensions that bear arms (163). **Miss.** (Osage).

E. pleurovimenus (White) [78—28]. Base flat; RR nearly vertical; tegmen inflated (163). **Burlington:** Ia., Mo.

E. millebrachiatus Wachsmuth and Springer [78—29]. Cup much higher than in *E. pleurovimenus* (163). **Burlington:** Ia., Mo.

E. tuberosus (Hall) [78—30]. RR form part of flat to slightly concave base; tegmen inflated (163). **Burlington:** Ia., Mo.

Subclass Uncertain

EDRIOCRINIDAE. Aberrant crinoids, probably reef-dwellers, attached by base of dorsal cup; BB four, commonly fused; X in line with RR; arms broad, branching, formed of short BrBr; crown may be free in adult stage. **L. Dev.**

EDRIOCRINUS Hall 1858

(**E. pocilliformis*). Only described genus of family (53, 131). **Dev.** (Helderberg).

E. sacculus Hall [79—27]. The largest species; BB form a fused mass; RR short, rectangular; arms broad, flat; commonly grows in cluster of individuals (25). **Oriskany:** N. Y., Md.

E. pyriformis Hall [79—28]. Base elongate; RR long, expanding upward but contracting at upper margins (25). **Coeymans:** N. Y.

E. dispansus Kirk [79—33]. Base low, discoid; RR narrowing upward (53). **Linden:** Tenn.

Suborder Articulata

Crinoids having a dorsal cup that is actually or potentially dicyclic, IBB and BB commonly altered by resorption and rebuilding, or absent; plates of dorsal cup normally massive; RR and BrBr perforated by separate dorsal canal; tegmen studded with minute calcareous particles, mouth and food grooves open; proximal columnal, when present, typically large and fused to dorsal cup. **Trias.–Recent.**

The articulate crinoids are feebly represented in the North American Mesozoic and Cenozoic formations. Described species are represented for the most part only by fragmentary remains.

BOURGUETICRINIDAE. Dorsal cup small; IBB absent; BB five or fused; RR five; arms 5 to 10; column lacking terminal plate, distal portion bearing cirri; columnals long, thin, articulating surfaces carrying a fulcral ridge; proximal portion of column expanded to full width of calyx. **Cret.–Recent.**

RHIZOCRINUS Sars 1864

(**R. lofotensis*). BB elongated, completely fused, forming large elongate base; RR small, four to seven; arms unbranching; column slender, composed of elongated segments (21). **Cret.–Recent.**

R. alabamaensis (Loriol) [79–1]. Known only from single basal cone to which are attached five fused columnals (21). **U. Cret.:** Ala. (Ripley).

R. cylindricus Weller [79—2]. Known from a single isolated dorsal cup and proximal columnal; calyx long, less convex and more slender than *R. alabamaensis*, lateral walls nearly straight (21). **U. Cret.:** N. J. (Rancocas).

APIOCRINIDAE. Column without cirri, greatly enlarged distally and attached to heavy terminal plate; columnals short, articular faces marked with radiating striae, without fulcral ridge; proximal columnals often expanded to full width of calyx; dorsal cup composed of heavy plates; IBB reduced in size, often fused with BB; PBrBr two; arms branching, commonly more than once. **Jura.–Recent.**

APIOCRINUS Miller 1821

(**Encrinites parkinsoni* Schlotheim). Stem fragments that mainly on the basis of their articular surfaces are referred provisionally to *Apiocrinus*, constitute the only known American occurrence of the genus (138). **Jura.**

A. tehuantepec Springer [79—7] (138). **U. Jura.:** Isthmus of Tehuantepec, Mexico.

PENTACRINIDAE. Column long, pentagonal to round, cirriferous throughout, without terminal plate; articular surfaces of columnals ornamented with quinquelobate figure; cup potentially dicyclic, IBB commonly resorbed; PBrBr one to eight, normally two; arms strong, pinnulate, branching (21). **Trias.–Recent.**

PLATE 80

[Figures are x1 and after Schuchert [USNM, B 88] unless otherwise indicated.]

1–4. Palaeaster niagarensis (x4). 1: Abactinal side of holotype restored; probably too many accessory disk pieces shown. 2: A few inframarginals and supramarginals from abactinal side. 3: Abactinal side of holotype. 4: Actinal side of a ray of the holotype. **5, 6. Hudsonaster spp. 5. H. matutinus.** A retouched photograph (x2) showing abactinal side. **6. H. narrawayi.** A greatly enlarged photograph of the genoholotype. **7, 8. Mesopalaeaster shafferi.** 7: Actinal area of a mature individual (x3). 8: Abactinal side of a third-grown individual (x8). **9–11. Devonaster eucharis.** 9, 10: Abactinal and actinal views. 11: Hall's diagram of the actinal plate arrangement; ambulacrals incorrectly drawn — should be opposite, not alternate (**a**, ambulacralia; **aa**, adambulacralia; **m**, inframarginals; **o**, pairs of oral armature ossicles; **p**, podial openings, but drawn a little too large; **tm**, the single interbrachial axillaries).

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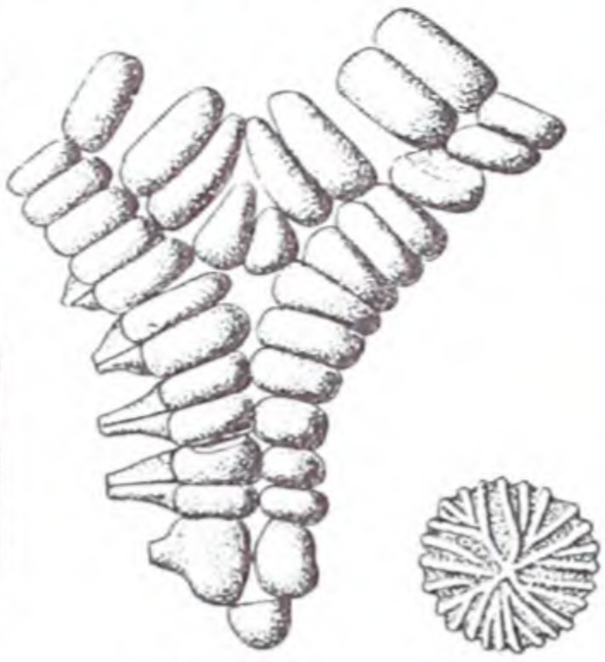

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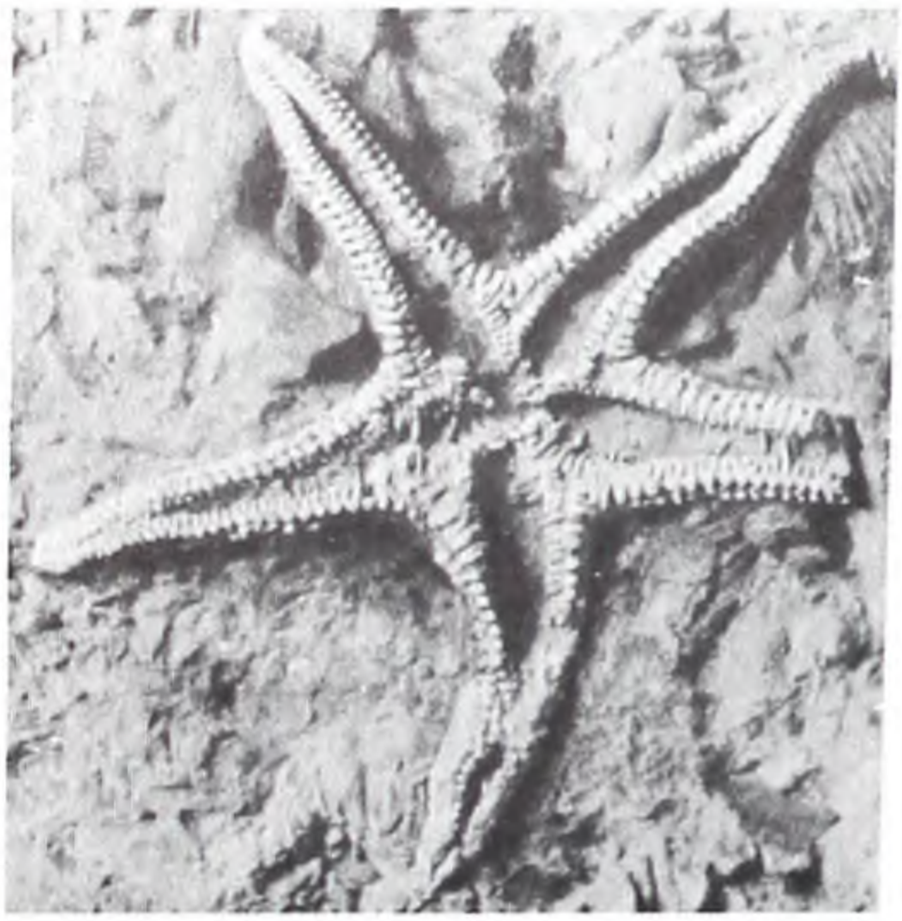

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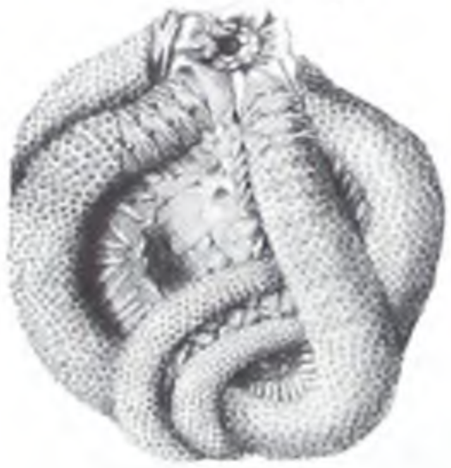

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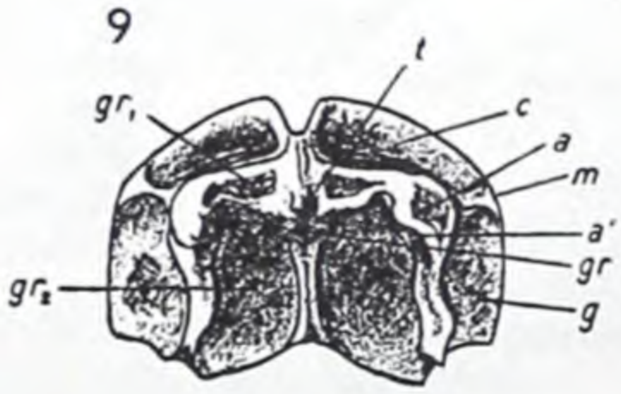

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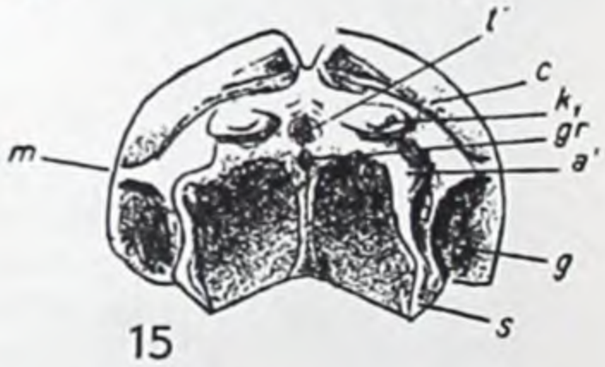

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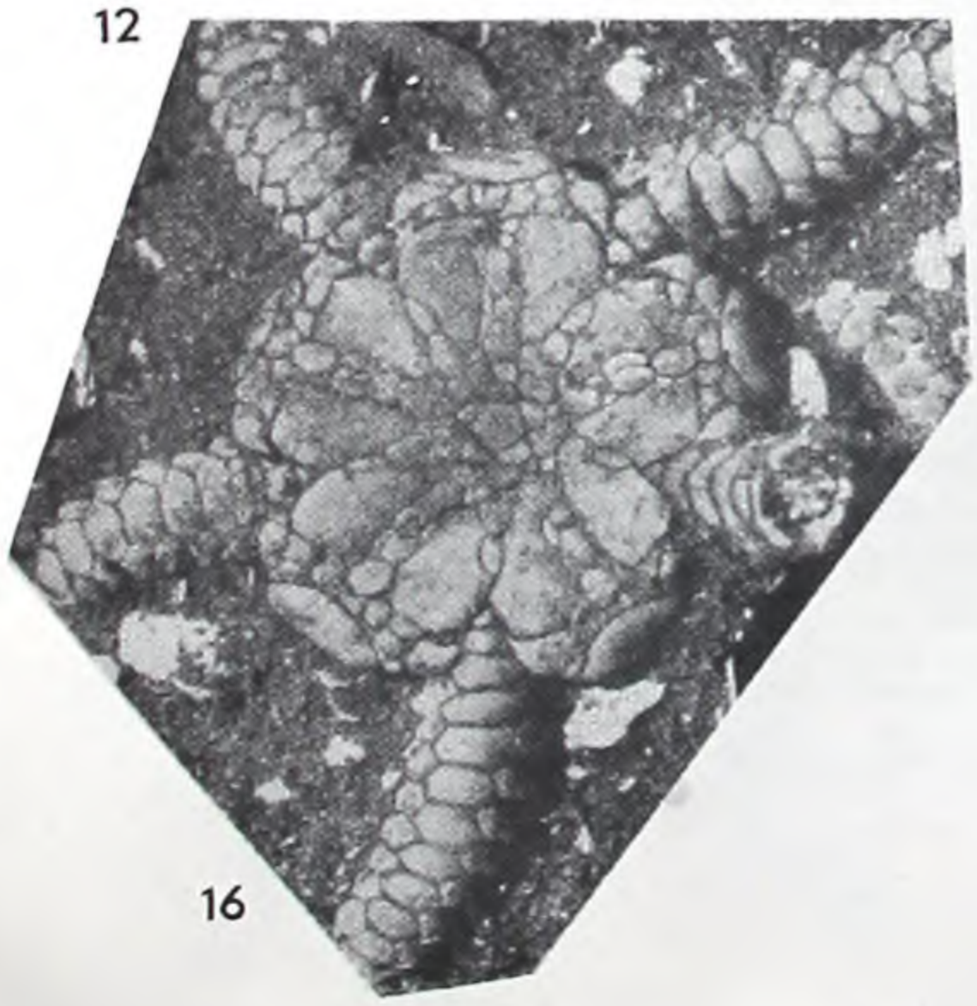

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PENTACRINUS Blumenbach 1804

(**P. briareus* Miller). Represented in North America mainly by isolated columnals, but specimens of *P. subangularis alaska* and *P. knighti* are more complete; *Pentacrinus* can be recognized by its long cirriferous column, by the distinct pentalobate ornamentation of its columnals, and its multiple branching arms (21). **Trias., Jura.**

P. subangularis alaska Springer [79—8]. Represented by numerous clusters of columnals and the fragmentary upper portions of the arms of one specimen (139). **L. Jura.:** Northern Alaska (Kingak).

P. californicus Clark [79—10] (21). **Jura.:** Cal. (Cedar).

P. asteriscus Meek and Hayden [79—6]. Known from columnals only (21). **U. Jura.:** S. Dak. (Sundance), Mont. (Ellis), Wyo., Idaho.

P. knighti (Springer) [79—3]. The only species in which more or less complete specimens have been found; it is distinguished by the less frequent whorls of cirri, presence of IBB, and RR that do not project down over first columnal; arms dichotomous, branching less frequently than normal for the genus (126). **U. Jura.** (Sundance): S. Dak., Wyo.

BALANOCRINUS Agassiz 1845

(**B. subteres*). Distinguished entirely on the ornamentation of the articular surfaces of the columnals; crenellae occur only along the outer margins of the pentalobate articular surfaces; known in N. America only from isolated columnals (21). **Trias.–Mioc.**

B. mexicanus Springer [79—5] (134). **U. Cret.:** Tamaulipas, Mex.

B. haitiensis Springer [79—4] (134). **Mioc.:** Haiti.

UINTACRINIDAE. Represented by the single genus *Uintacrinus*; these peculiar stemless crinoids cannot be compared well with any other known form; base perfectly pentamerous, IBB fused into single small pentagonal plate or absent; BB and RR five each, in lateral contact; PBrBr two, followed by long straight series of SBrBr, which eventually become free arms; fixed pinnules given off from SBrBr within calyx; IBrBr and ISBrBr well developed; arms 10, unusually long, pinnulate, reaching a length of 1.2 m (4 ft) (124). **Cret.** (N. America; Europe).

UINTACRINUS Grinnell 1876

***U. socialis** Grinnell [79—31] (124). **Cret.:** Kan. (Smoky Hill), Wyo.

MARSUPITIDAE. Stemless crinoids; large pentagonal central plate inside IBB circlet; five large IBB, five large BB, five slightly smaller RR; XX and IBrBr absent in cup; PBrBr two, not incorporated in cup; arms small, short, pinnulate. **U. Cret.** (N. America; Europe).

MARSUPITES Miller 1821

(**M. testudinarius*). The only known genus in the family (21). **U. Cret.** (N. America; Europe).

M. americanus Springer [79—26] (128). **U. Cret.:** Miss. (Tombigbee).

Fragmentary Remains

Almost all specimens of fossil crinoids are incomplete, but genera and species may be differentiated reliably if features that are deemed to have diagnostic value are shown by the specimens. Fragmentary remains, consisting of individual plates or of united plates forming part of a dorsal cup, tegmen, arm or stem, commonly are not identifiable with certainty, even though the fragment may belong to a described species. Nevertheless, these fragmentary remains are worthy of study because they are abundant in many strata that lack well preserved crinoids and because kinds of crinoidal fragments from different horizons are frequently distinguishable readily. They have stratigraphic value.

Individual plates or groups of attached plates may be classified best according to morphologic characters in groups such as (1) stem fragments, (2) plates at the base of a cup, indicated by markings of the stem attachment, (3) plates bearing an arm facet, and similar assemblages. Distinguishable kinds of fragments within each group may be indicated by a name, but inasmuch as the groups have no definite relation to a phylogenetic classification of crinoids, the names must not conflict with the International Rules of Zoological Nomenclature, nor should they be confused with designations for crinoids that are formulated according to the Rules (102). On the other hand, genera and species of crinoids have been defined on the basis of extremely fragmentary specimens. This is especially true of North American Articulata.

Examples of named crinoid fragments that mostly represent unknown genera and species are described briefly and illustrated.

Group Columnals. Skeletal elements belonging to

PLATE 81

[Figures are x1 and after Schuchert [USNM, B 88] unless otherwise indicated.]

1. Stenaster salteri (x3). Retouched photograph showing actinal surface. **2–5. Promopalaeaster bellulus.** 2: Retouched photograph of actinal side. 3: An interbrachial area of 2 (x4). 4: Madreporite (x7). 5: Abactinal area of a ray (x7), with ossicles displaced. **6, 7. Urasterella pulchella.** Actinal and abactinal views of different specimens. **8. Taeniaster spinosus.** Actinal view (x2). **9–15. Onychaster flexilis.** 9, 10: Two views of a specimen with arms intertwined [Ill G S 1]. 11, 12: Side and ventral views of two proximal vertebrae. 13: Ventral view of several successive vertebrae. 14, 15: Proximal vertebrae seen from aboral and adoral surfaces. **16. Ophiura marylandica** (x3.7) [Am Phil Soc, Pr 80]. Dorsal view. **17, 18. Amphiura sanctaecrucis** [USGS, M 54]. Ventral surface (x0.5) and dorsal surface (x1.5).

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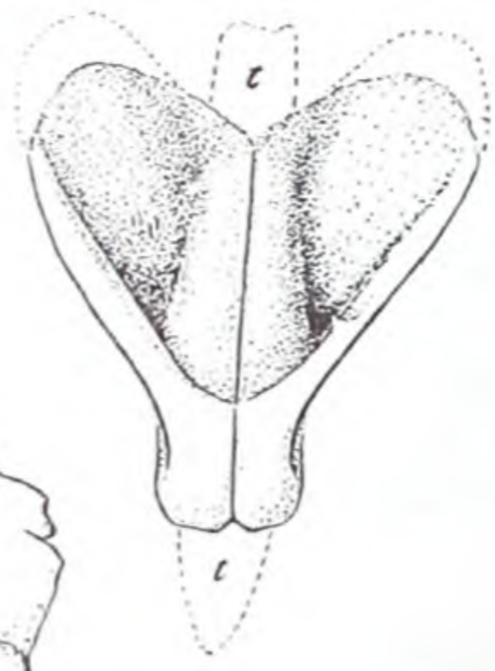
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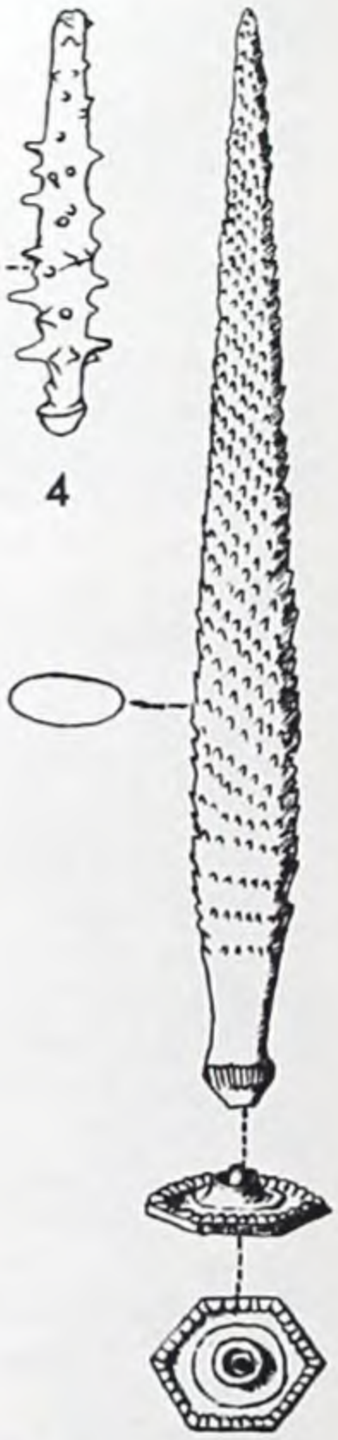
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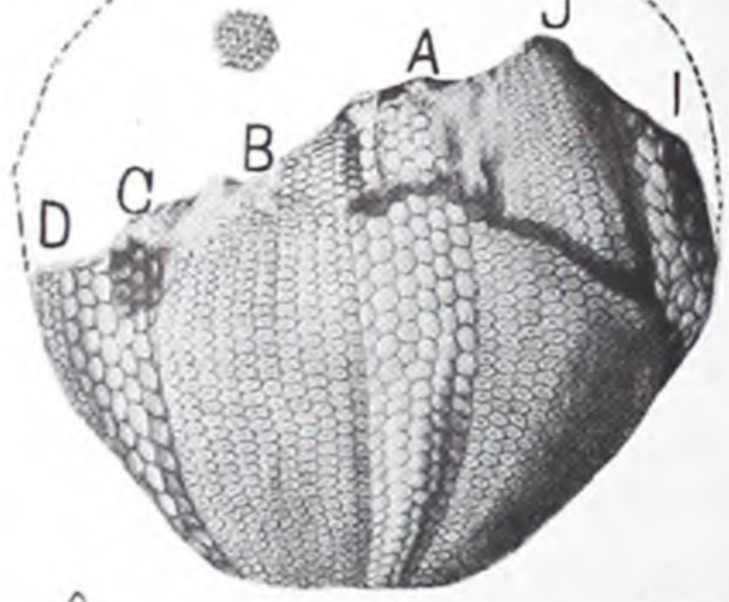
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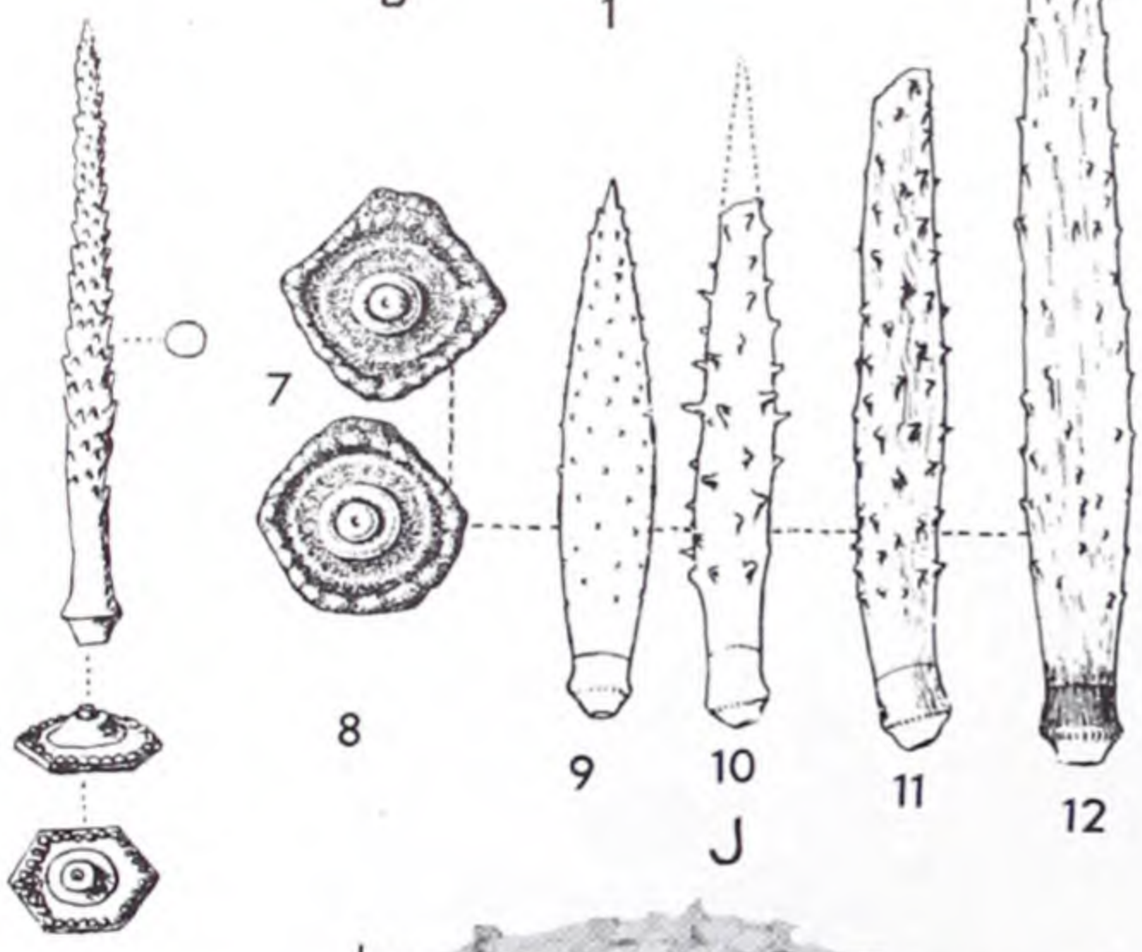
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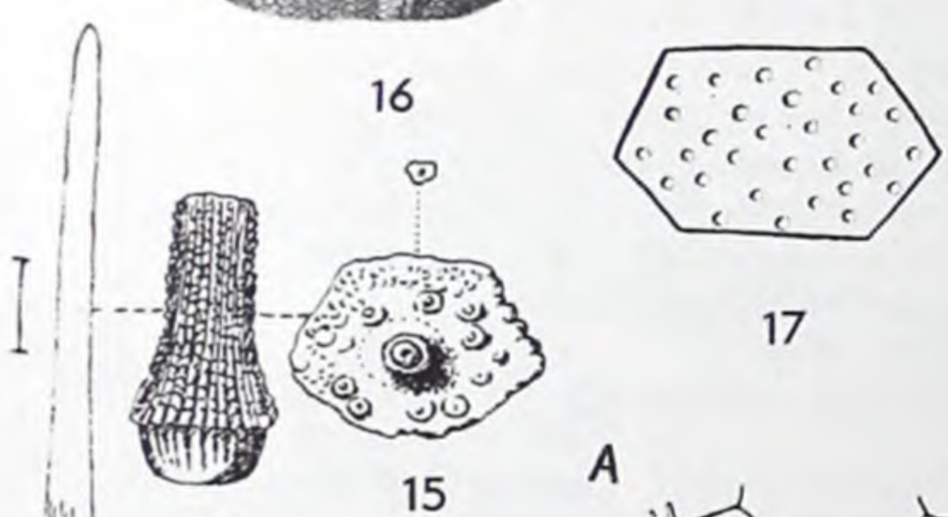
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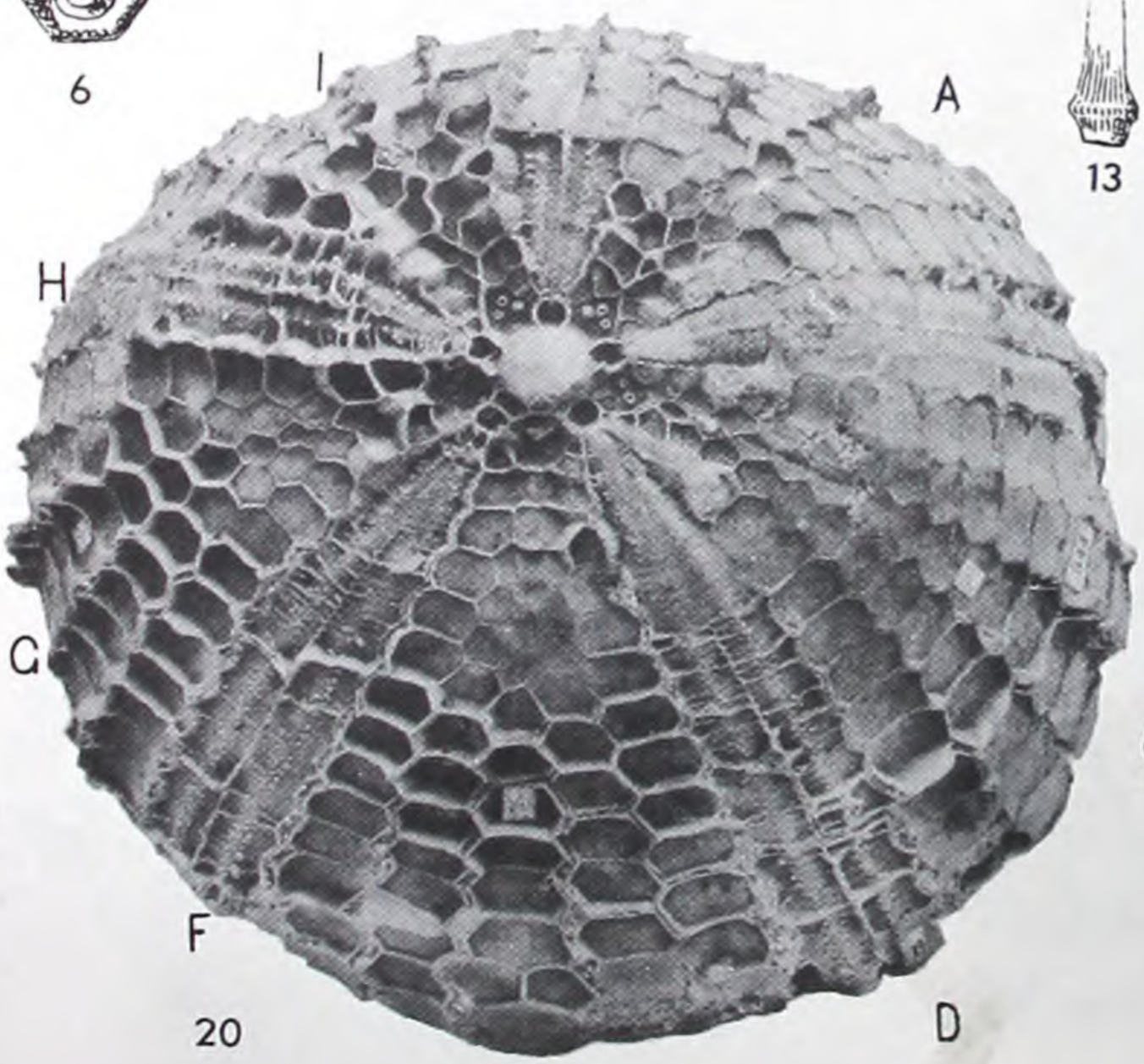
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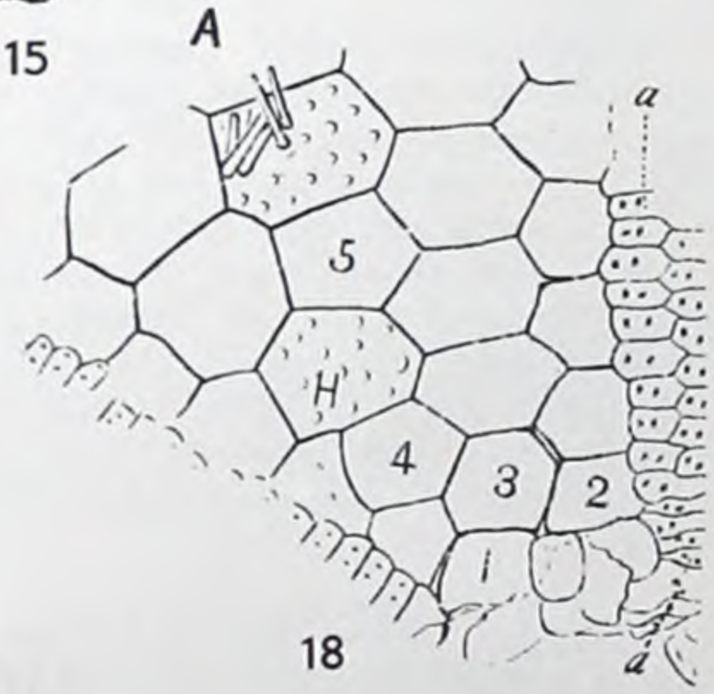
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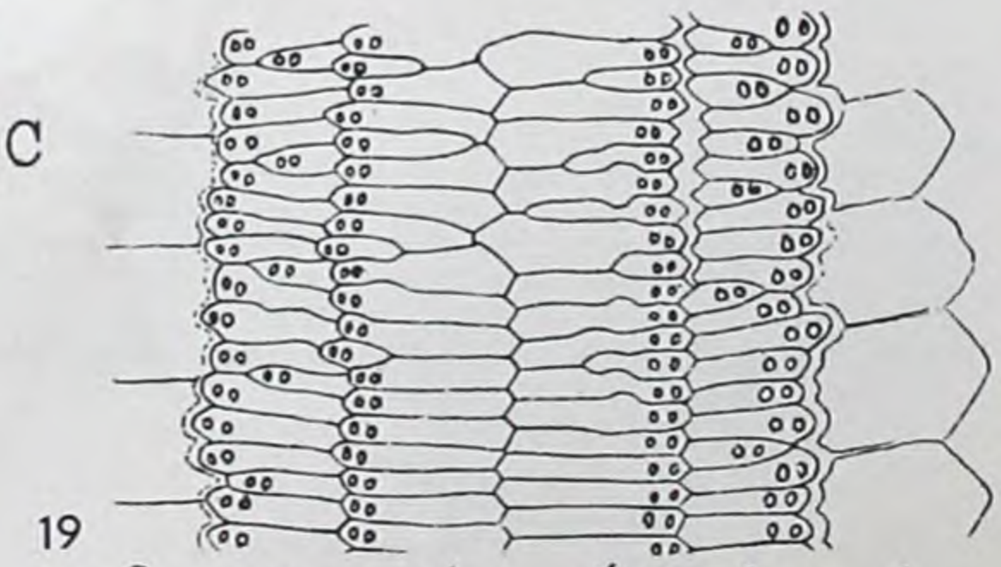
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the crinoid stem, including cirri and structures for anchorage or attachment; plates of some stems divisible into nodals, distinguished by cirrus scars, and internodals.

Columnal dispar (Moore) [79—9]. Pentagonal outline, articular surface distinctive; nodals thick, bearing five elliptical cirrus facets (102). **Penn.:** Kan. (Coffeyville).

Columnal granulosus (Moore) [79—13]. Circular, thin; crenellae even, short; lumen pentalobate, surrounded by granulose area (102). **Penn.:** Okla. (Savanna).

Columnal excentricus (Moore) [79—14]. Eccentric depressed area containing pentalobate lumen (102). **Penn.:** Kan. (Mineral Coal cap).

Columnal spicatus (Moore) [79—20]. Outline sinuate circular, articular surface elliptical, marked by longitudinal ridge (102). **Penn.:** Kan. (Coffeyville).

Ancyrocrinus spinosus Hall [79—30]. Column provided with recurved massive spines at base (34). **Dev.:** N. Y.

Camarocrinus ulrichi Schuchert [79—34]. Large ovoid sac, covered by many small plates and divided by vertical walls into chambers, to which the stem of *Scyphocrinus* is attached; presumably functioned as a float (123). **Dev.:** Okla. (Haragan).

Group Apicals. Plates belonging to the lowermost circlet of a dorsal cup, generally marked by presence of a stem impression; includes BB of monocyclic crinoids and IBB of dicyclic crinoids.

Apical urna (Moore) [79—21]. Circlet composed of three equal plates, bearing round stem impression; low bowl-shaped (102). **Miss.:** Mo. (Burlington).

Apical glyptus (Moore) [79—24]. Nearly flat circlet consisting of five plates, each bearing three ridges; stem impression subpentagonal (102). **Penn.:** Kan. (Mineral Coal cap).

Apical regularis (Moore) [79—25]. Low conical circlet, five plates, surface smooth; stem facet round (102). **Penn.:** Okla. (Stanton).

Group Polygonals. Plates of dorsal cup (or tegmen) that have a polygonal outline and that are not referable to other categories.

Polygonal tenuirugosus (Moore) [79—22]. Thick plate lacking stem markings or arm facet; surface ornamented by irregular low ridges (102). **Penn.:** Ia. (Missouri).

Group Facetals. Plates of dorsal cup bearing a single arm facet (or a number of facets in Allagecrinidae) on one margin; includes RR of Disparata and Cladoidea and certain BrBr of Camerata.

Facetal tuberculatus (Moore) [79—15]. Plane of facet nearly at right angle to outer surface of plate, which bears prominent round tubercles (102). **Penn.:** Kan. (Mineral Coal cap).

Facetal corrugatus (Moore) [79—16]. Like *F. tuberculatus* but surface marked by fine tubercles and low corrugation parallel to borders (102). **Penn.:** Kan. (Coffeyville).

Facetal lineatus (Moore) [79—18]. Facet makes large oblique angle with outer surface of plate, narrower than greatest width of plate; ridges on outer surface (102). **Penn.:** Okla. (Oologah).

Facetal canalis (Moore) [79—23]. Facet narrow, arcuate, concave; outer surface of plate smooth (102). **Penn.:** Kan. (Mineral Coal cap).

Group Brachials. Plates of rays having two or three articulating facets on margins.

Brachial acutus (Moore) [79—19]. Sharply pointed spine; three articular facets at proximal edge of plate (102). **Penn.:** Kan. (Mineral Coal cap).

Brachial simus (Moore and Plummer) [79—11]. Barrel-shaped plate, transversely truncate distally, three facets at proximal edge (102). **Penn.:** Ark. (Brentwood).

Stereobrachicrinus pustullosus Mather [79—12]. Arm consisting of fused quadrate BrBr — the only known part of the crinoid and on this basis described as a new genus and species. It is reasonable to consider such a fragment too inadequate for diagnosis of a genus and species; informal designation as *Brachial pustullosus* would be preferable (80, 102). **Penn.:** Ark. (Brentwood).

Group Tegminals. Plates of the tegmen, including OO, sac plates, and others that are identifiable as belonging to this part of calyx.

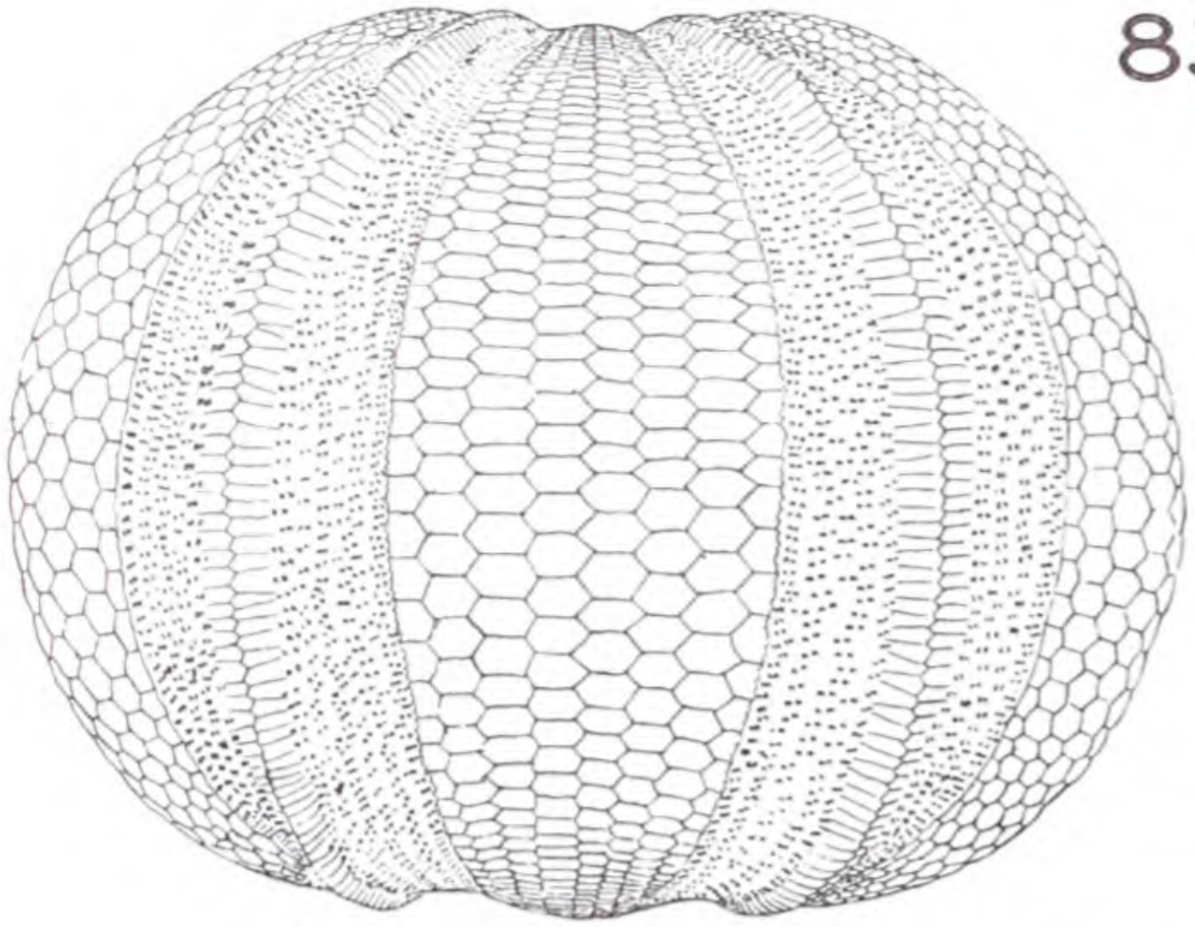
Tegminal expansus (Moore) [79—17]. Spade-shaped sac spine, distinguished by its form (102). **Penn.:** Kan. (Mineral Coal cap).

Group Composites. *Ageneracrinus subtumidus* (Worthen) [79—29]. Dorsal cup having characters of the cup in *Eupachycrinus*, *Phanocrinus*, and *Pentaramicrinus*, but lacking arms, which furnish basis for differentiating these genera (153). **Miss.:** Ill. (Chester).

PLATE 82

[Figures are x1 and after or from Jackson [Boston Soc N H, M 7] unless otherwise indicated. Several of Jackson's figures are after other authors.]

1–16. Echinocrinus spp. **1–3. E. agassizi.** 1: Fragment showing ambulacra and four columns of interambulacral plates (x1.8). 2: Pyramid with tooth (dotted) in place (x3.8). 3: Four views of a spine (x1.8). **4, 5. E. dininni.** Primary spines (x0.9). **6. E. shumardana.** Spine (x1.9). **7–12. E. aculeata.** Dissociated plates and spines (x1.9). **13–15. E. halliana.** Spine (x6) and portion of same greatly enlarged; interambulacral plate x1 and much enlarged. **16. Lepidesthes coreyi** [Ill G S 5]. Incomplete specimen, with outline restored, and an interambulacral plate with secondary tubercles enlarged. **17–19. Oligoporus danae.** Interambulacral plate (x3.3); interambulacral area (x2.5); ambulacral area (x2.4). **20. Lovenechinus missouriensis.** Summit view of an old age individual.



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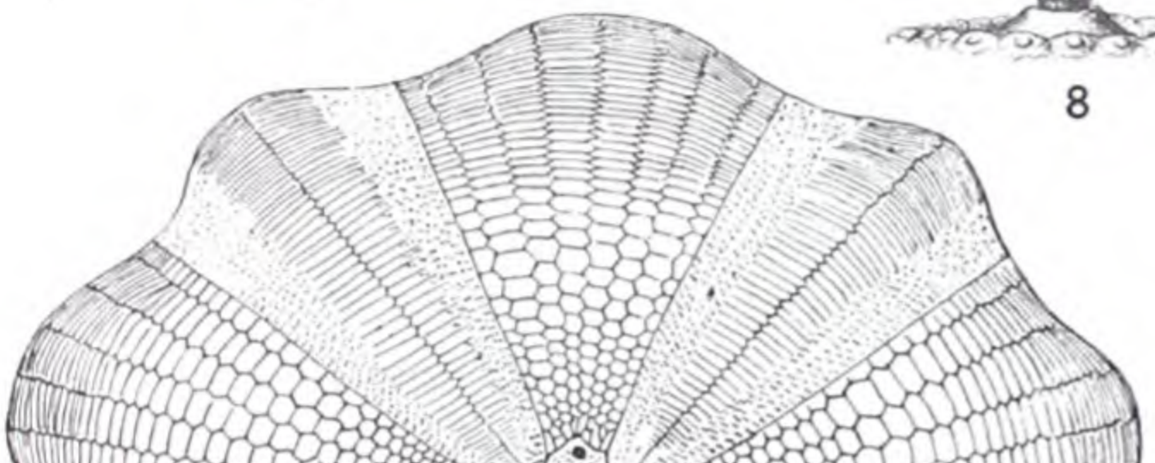

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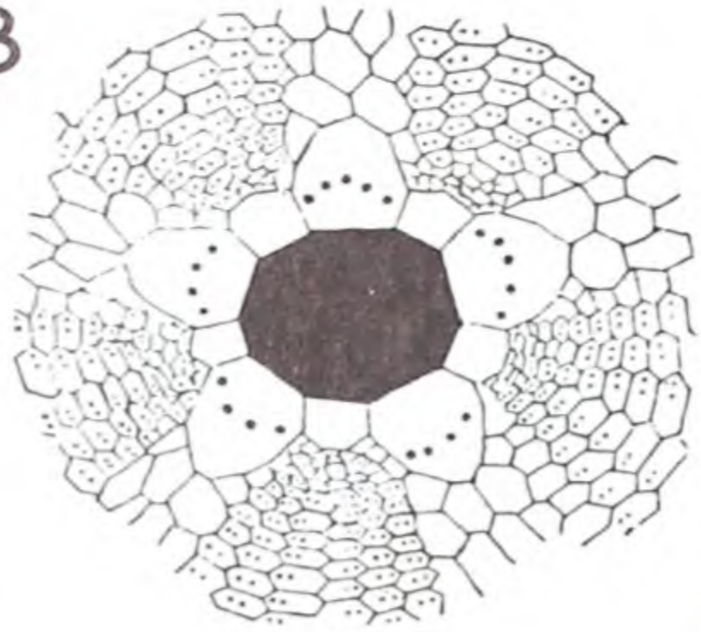

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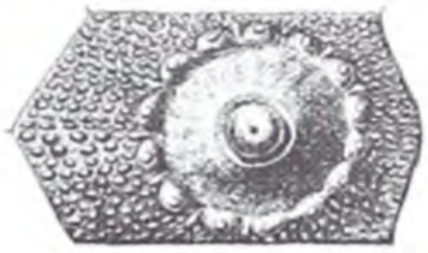

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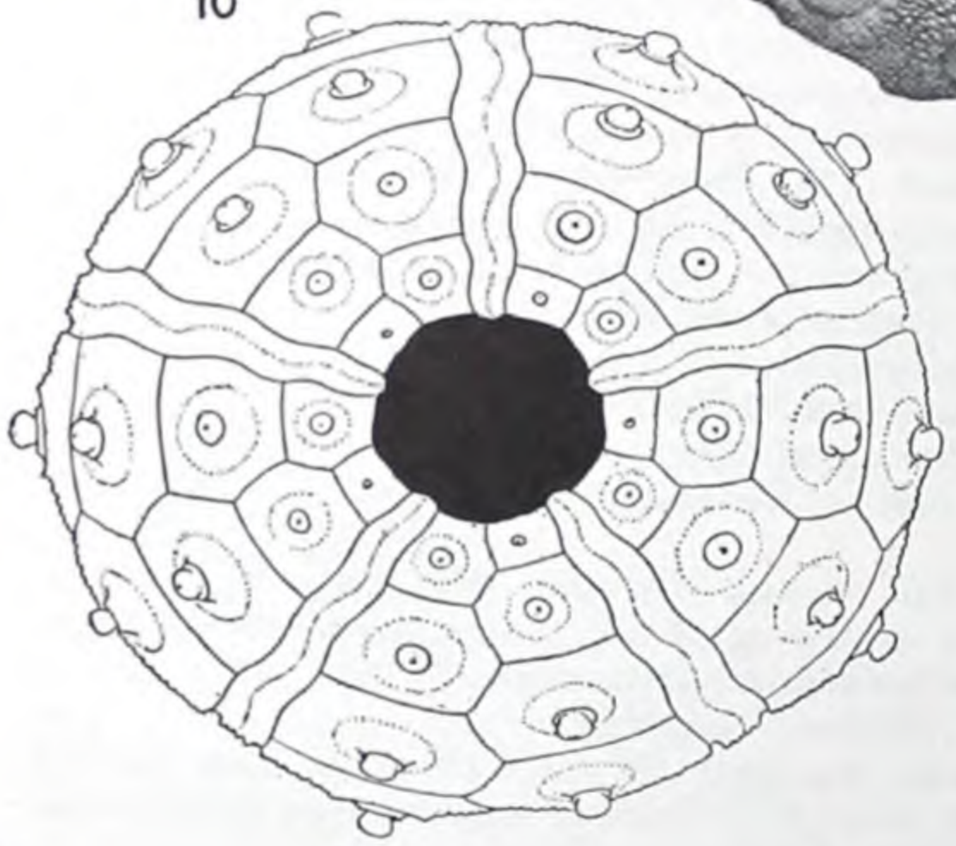

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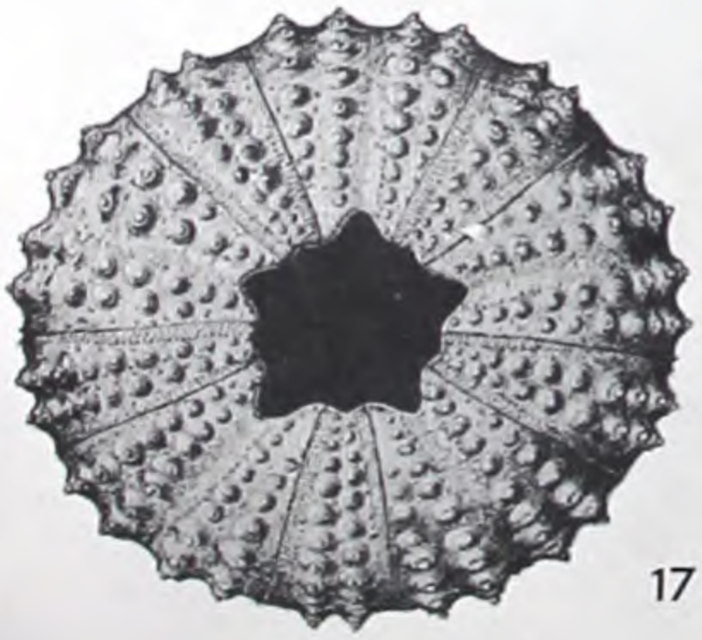

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SUBPHYLUM ELEUTHEROZOA

CLASS STELLEROIDEA[1]

Subclass Asteroidea

Asteroids have simple arms which, as prolongations of the central disk, contain extensions of the digestive cavity and generative organs. The ventral border of the arms is marked by the ambulacral groove which is formed by two rows of ambulacral ossicles; laterally, these ossicles are bordered by adambulacral or marginal plates (at the outer edge of the arm). All except the ambulacral plates may bear movable spines. Between the ambulacral ossicles are grooves for passage of the tube feet, in either a single or a double row on each side of the median line. The dorsal surface is formed by a network of ossicles, often with spines and other appendages. The madreporite is situated dorsally in one of the interrays.

Complete asteroid skeletons are not often preserved but it is quite likely that individual plates are scattered throughout the geologic column, and they may be expected in rocks of Cambrian to Recent age.

HUDSONASTER Stürtz 1900

(**Palasterina rugosa* Billings). Disk small and without actual interbrachial arcs; rays five, short, tapering rapidly; skeleton composed of many calcareous plates, some of which are illustrated in the following species. **M.** and **U. Ord.**

H. narrawayi (Hudson) (**80**—6). **Stones River:** Tenn.; **Black River:** Ont.; Minn. (A variety occurs in Galena of Wis.)

H. matutinus (Hall) (**80**—5). **Trenton:** Que., Ont.; N. Y.

PALAEASTER Hall. 1852, emend Schuchert 1915

(not = PALAEASTER of most authors)

(**P. niagarensis*). Actinally like *Hudsonaster*; abactinally like that genus also, but without radial columns. **Sil.**

***P. niagarensis** Hall (**80**—1–4). **Niagaran:** Ont.; N. Y. (Lockport).

MESOPALAEASTER Schuchert 1914

(**Palaeaster shafferi* Hall). Rays five, tapering; disk small with incipient interbrachial arcs; single axillary plates usually pushed inward (interbrachial) and their former place occupied by proximal plates of adjoining inframarginal columns. **U. Ord.–?L. Dev.** (N. America).

***M. shafferi** (Hall) (**80**—7, 8). **U. Ord.:** N. Y. (Utica), Ohio (Cincinnatian).

DEVONASTER Schuchert 1914

(**Palaeaster eucharis* Hall). Readily distinguished from *Hudsonaster* in having well developed radial and ambital accessory plates, in the many very small plates of the disk, and in the presence of interbrachial axillary plates. **Dev.**

***D. eucharis** (Hall) (**80**—9–11). **Hamilton:** Ont.; N. Y.

PROMOPALAEASTER Schuchert 1914

(= PALAEASTER (part) of authors)

(**Palaeaster granulosus* Meek (not Hall) = *P. speciosus* Meek). Disk with distinct and angular interbrachial arcs; rays five, slender to stout, long, tapering; interbrachial areas complex and composed of single axillary interbrachials; more than one pair of interbrachial marginals and adambulacral plates; podial openings mainly in two columns but proximally there may be two additional ones in a length never more than one-third the rays. **M.** and **U. Ord.**

P. bellulus Schuchert (**81**—2–5). **Richmond:** Ohio, Ind. (Fragments of *P. bellulus*, *P. speciosus*, and *P. spinulosus* are usually indistinguishable.)

STENASTER Billings 1858, emend Schuchert 1915

(**S. salteri*). Small rigid asterids; disk small, without interbrachial arcs; rays five, short, stout, lanceolate or petaloid; abactinal area devoid of preservable skeleton. **Ord.**

***S. salteri** Billings (**81**—1). **M. Ord.:** Ont.; Vt., N. Y.

URASTERELLA McCoy 1851,

emend Schuchert 1915

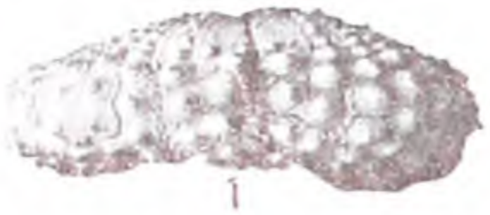
(**Uraster ruthveni* Forbes). Distinguishable from all other Paleozoic genera by the long, slender, and flexible rays, apparent absence of inframarginal columns, and absence of distinct interbrachial plates. **Ord.–Penn.** (N. America; Europe).

[1] **Berry, C. T.,** Miocene and Recent *Ophiura* skeletons: *Johns Hopkins U, Stud Geol* 11: 11–136, pl 1–6, 1934; Cretaceous ophiurans from Texas: *JP* 15: 61–67, il, 1941. **Clark, H. L.,** Catalogue of Recent ophiurans: *MCZ* (*Harvard*), M 24 (4): 1–376, pl 1–20, 1915. **Schuchert, C.,** Stelleroidea Palaeozoica: *Fos Cat*, pars 3: 1–53, 1914; Revision of Paleozoic Stelleroidea with special reference to North American Asteroidea: *USNM*, B 88: 1–301, pl 1–38, 1915. **Spencer, W. K.,** A Monograph of the British Palaeozoic Asterozoa. *Palaeontogr Soc*, Pts I–X (incomplete), 1–540, pl 1–37, 1914–1940, London. **Weller, J. M.,** Ophiuroid remains of Pennsylvania age: *JP* 4: 1–13, il, 1930.

PLATE 83

[Figures are x1 and after Clark [USGS, M 54] unless otherwise indicated.]

1–3. Melonechinus multiporus. Lateral and summit views [Mo G S 4], and apical view [Ill G S 2]. **4–7. Cidaris spp. 4. C. dilleri.** Portion of test. **5–7. C. californicus.** Articular surface of 7 (x2), and spines. **8–11. Dorocidaris texanus.** Tubercule (x3); portion of ambulacrum (x6); interambulacral plate, slightly enlarged; test restored and slightly enlarged. **12, 13. Cidaris splendens** [JP 15]. Several interambulacral plates with tubercles, and a spine (x2). **14, 15. Phyllacanthus mortoni** [JP 15]. Side and bottom views. **16. Leiocidaris hemigranosus.** Side view (x0.75). **17–19. Phymosoma texanum.** Upper, lower, and lateral surfaces of test.



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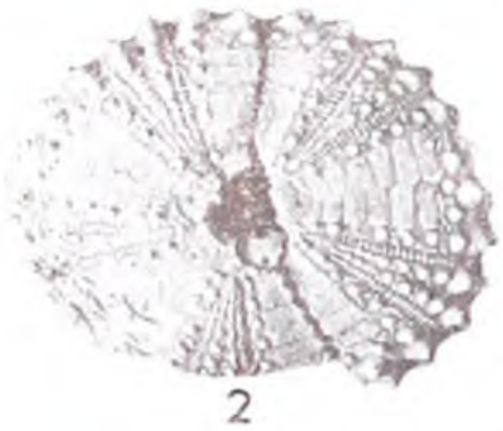

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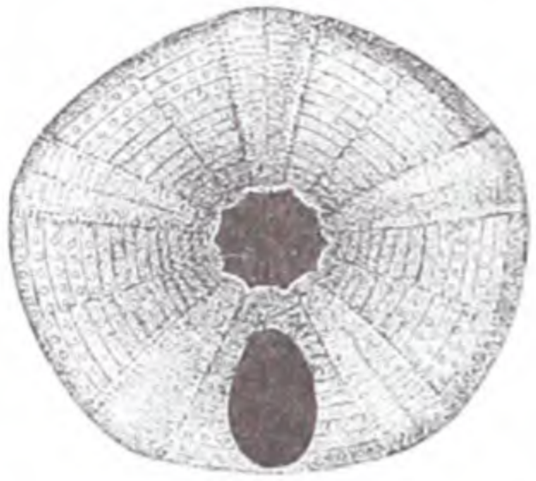

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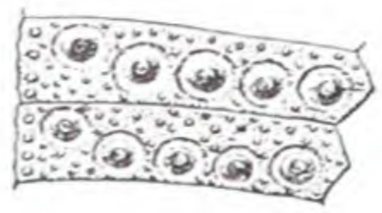

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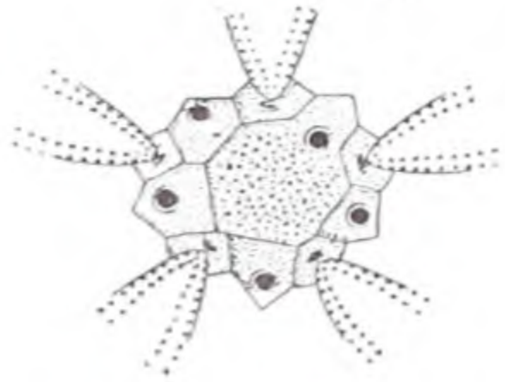

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U. pulchella (Billings) (**81**—6, 7). **Trenton:** Ont.; N. Y.

Subclass Auluroidea

The central disk is fairly well defined and from it extend five unbranched arms. Ambulacral grooves are formed by two rows of plates which alternate in position and are bordered on the outer margin by a single row of marginal plates. The madreporite is small and on the oral side. The auluroids make their appearance as fossils in the late Ordovician and apparently disappear before the close of the Paleozoic. They are rare as fossils.

TAENIASTER Billings 1858

(**Palaeocoma spinosa*). Body stellate, disk small; no marginal plates; rays long, slender, flexible, and spinose; large ambulacral pores in two rows; adambulacral ossicles contracted in middle, dilated at each end. **Ord.** (Que.; N. Y., Pa., Ohio).

***T. spinosus** (Billings) (**81**—8). **Trenton:** Que.

Subclass Ophiuroidea

Ophiurans or brittle stars constitute a group of echinoderms abundantly represented in modern faunas but rarely preserved as fossils. A sharply defined central disk contains the mouth and digestive cavity; the latter does not extend into the slender rounded arms. The arms consist of an axis of jointed calcareous disks (*vertebral ossicles*) surrounded by plates or by a leathery integument; they are without open ambulacral grooves. The madreporite is situated on the oral (actinal) side of the disk. The arms are movable and serve for locomotion; they may be intertwined.

Complete skeletons of ophiuroids are rare but individual plates, of which there are many different kinds, have been reported as fossils from formations as old as the Mississippian. The subclass probably developed in the Devonian and is abundantly represented in later Tertiary and Recent deposits.

ONYCHASTER Meek and Worthen 1868

(**O. flexilis* M and W [**81**—9–15]). Body small, subdiscoid, with five long, slender, rounded flexible arms or rays; arms folded together clawlike or opened out; dorsal surface studded with many calcareous plates. **Miss.** (Keokuk): Ind.

OPHIURA Lamarck 1801

(**O. texturata* Lyman = *Asterias ophiura* Linnaeus). One of the commonest of the living brittle stars, which has also been reported fossil from Tertiary deposits.

O. marylandica Berry (**81**—16). **Mioc.:** Md. (St. Marys).

AMPHIURA Forbes 1843 (restricted)

(**A. chiajii*). One apical or subapical mouth papilla; one (rarely two) small, distal papilla (oral tentacle-scale); middle of jaw-edge without papillae; mouth-slits gaping; four to seven or more (rarely three) arm-spines; radial shields divergent. **Mioc.–Recent.**

A. sanctaecrucis Arnold (**81**—17, 18). **Mioc.:** Cal. (Santa Margarita).

CLASS ECHINOIDEA[1,2]

Echinoids (sea urchins) are free-moving echinoderms with a hollow, globular to discoidal shell or test which is composed of numerous thin, closely joined calcareous plates. They differ in general appearance from crinoids and most other pelmatozoans in lacking stem and arms and in having surficial spines.

The main part of the test is the *corona*; it is supplemented by a system of plates, the *apical system* (**87**—10), which lies near the center of the dorsal or *abactinal* surface. The test has two large openings which during life are covered, except at their centers, with leathery membranes studded with calcareous plates The part around the mouth is the *peristome*; that around the anus the *periproct*.

The mouth is centrally or eccentrically situated on the ventral or *actinal* side of the test. In life it contains a very complicated dental apparatus, "Aristotle's Lantern," consisting of five hard, interradially situated *teeth* which are attached to a similar number of *pyramids* resting upon the membrane surrounding the mouth. Muscles connect the pyramids with each other and with projections from the solid test surrounding them.

The anus is surrounded by a soft membrane similar to that around the mouth and lies either at the center of the apical system or at a variable distance from it in the median line of the posterior interambulacrum, on either the upper or under surface

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[1] We have had assistance from Drs. H. L. Clark, C. Wythe Cooke, and L. W. Stephenson in revising this class. To these investigators we extend our grateful appreciation.

[2] **Adkins, W. S.,** Texas Comanchean echinoids of the genus *Macraster: U Tex B* 3001: 101–120, il, 1930. **Arnold, B. W., and Clark, H. L.,** Jamaican fossil Echinii; description of new species of Cainozoic Echinoidea: *MCZ (Harvard)*, M 50: 1–84, pl 1–22, 1927; Some additional fossil Echinii from Jamaica: Idem, M 54: 139–156, il, 1934. **Clark, W. B.,** Mesozoic Echinodermata of United States: *USGS*, M 54: 1–100, pl 1–54, 1915. **Clark, W. B., and Twitchell, M. W.,** Cenozoic Echinodermata of United States: Idem: 101–341, pl 55–108, 1915. **Cooke, C. W.,**

PLATE 84

[Figures are x1 and after Clark and Twitchell [USGS, M 54] unless otherwise indicated.]

1–3. Arbacia improcera [JP 15]. Side, top, and bottom views. **4–9. Holectypus planatus.** Top and bottom; two interambulacral plates (x3); apical system (x5); lateral surface of test; portion of ambulacrum (x5). **10. Echinarachnius fairbanksi.** Upper surface. **11–13. Psammechinus philanthropus.** Side, top, and bottom views. **14–18. Clypeaster** spp. **14–16. C. rogersi.** Side, top, and bottom views. **17, 18. C. browersi** (x0.5) [U Cal Pub g s 12]. Top and side views. **19–21. Periarchus lyelli.** Side, top, and bottom views of a small form.

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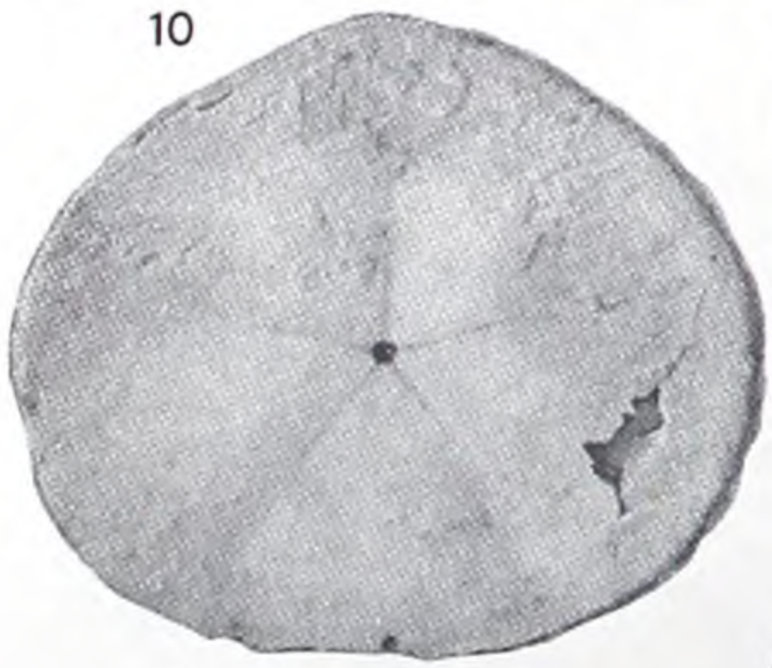

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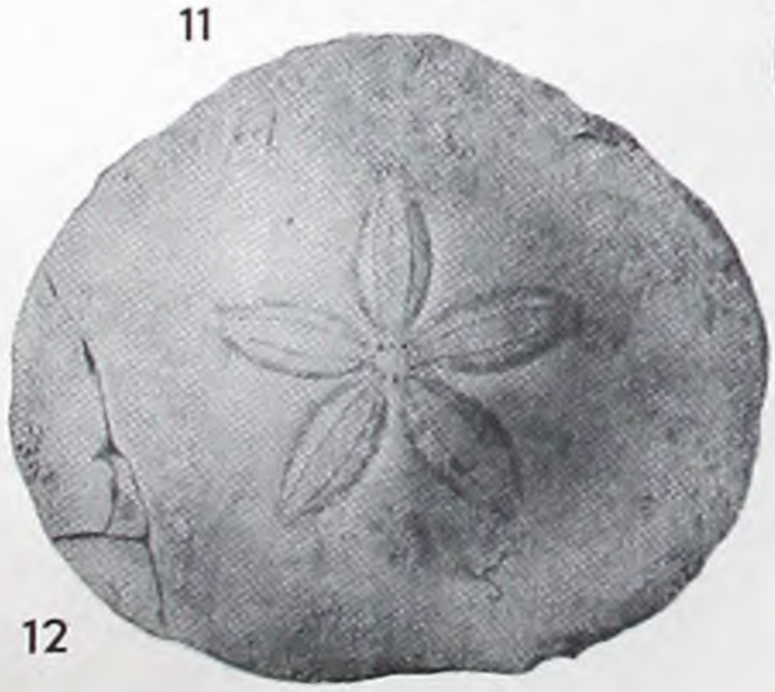

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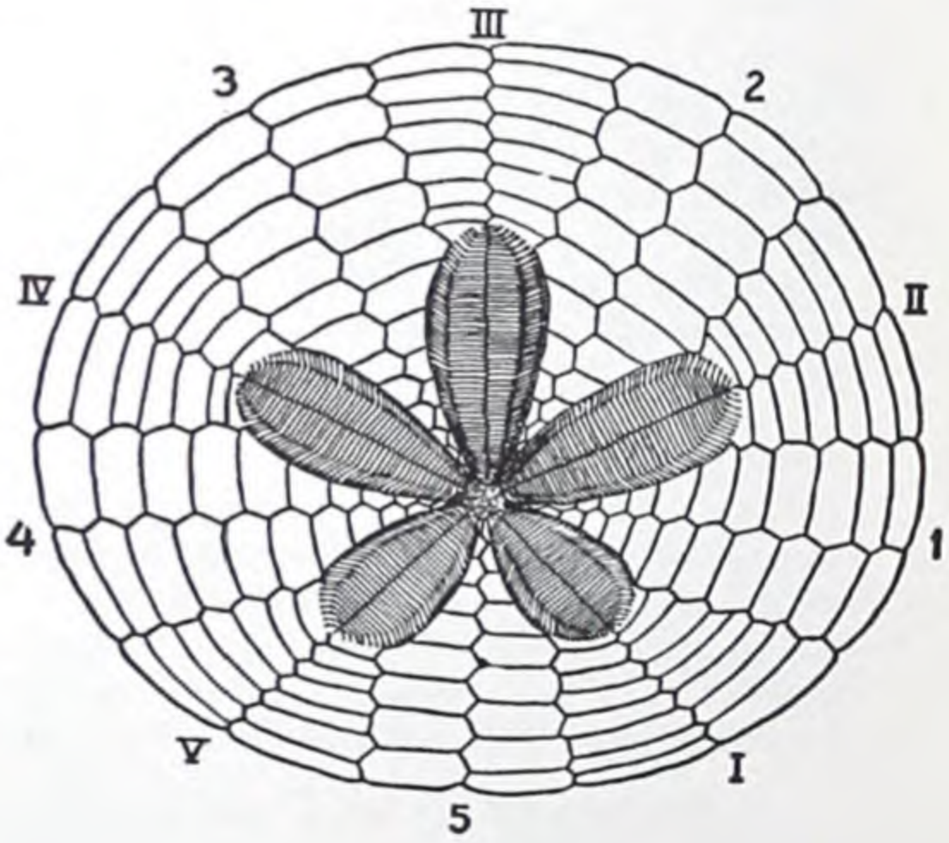

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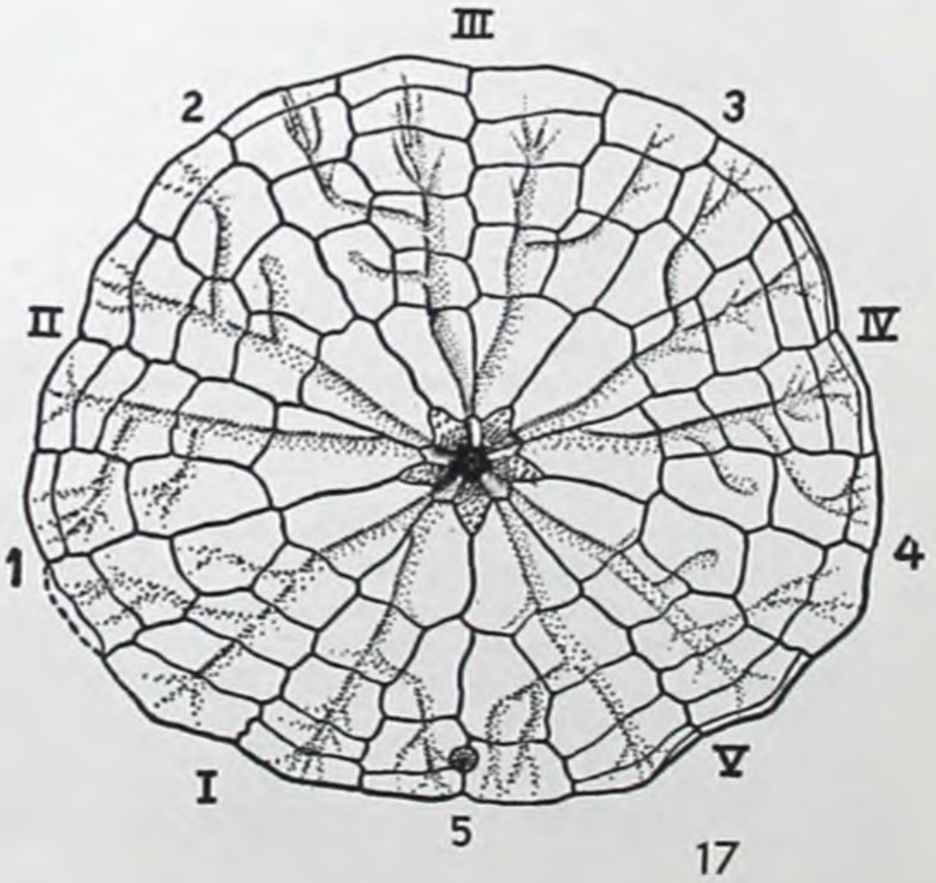

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of the test. Regular or *endocyclic* tests have the mouth centrally placed and the anus at the center of the apical system. Irregular or *exocyclic* tests have the mouth central or eccentric and the anus eccentric.

Test plates are arranged in 10 meridianlike zones. Five of these zones, the ambulacral areas (hereafter designated *Amb*), are composed of small perforated plates; the other five, constituting the interambulacral areas (hereafter designated *IAmb*), alternate with the *Amb* and consist of somewhat larger imperforate plates. Each zone is generally composed of 2 columns of plates, making 20 columns in all — 10 perforate and 10 imperforate. This number, however, is not attained in some forms and is exceeded in others.

IAmb plates are always simple; *Amb* plates may be simple or compound. Compound plates in some forms consist of two or more parts, all of which are joined by sutures and form a more or less polygonal plate. New plates are added successively to the ends of the *Amb* and *IAmb* next to the apical system.

Each *Amb* consists of an interporiferous area lying between two poriferous areas; only a few Paleozoic genera have the whole *Amb* pore-bearing. Usually the *Amb* pores are in pairs. The arrangement of these pairs may be in simple series, with one pair placed over the other in succession from mouth to apex; or in biserial, if so placed that there are two vertical rows of pairs. Simple series of pores are either absolutely straight or in curves or arcs of three or more pairs. *Amb* are simple if band-shaped and continuous from center of top to center of bottom. Petaloid *Amb* have pore-bearing zones separate between apex and circumference (*ambitus*) of test and contracted more or less perfectly before reaching that region. Subpetaloid *Amb* are comparatively larger than petaloid, and the pairs of pores do not tend to close again toward the ambitus. The pores almost cease at the end of the petaloid parts, though a few usually can be traced farther, at times even to the mouth. The anterior *Amb* of irregular echinoids is generally less fully developed and lies in an anterior sulcus (87—24).

In some echinoids (e.g. *Cassidulus*) the group of *Amb* plates bordering the mouth are petaloid and swollen (*phyllodes*) with pores crowded and prominent. This complex is the *floscelle*. The five phyllodes are separated by inflated *IAmb* plates designated *bourrelets*.

The apical system usually consists of 10 plates arranged in two alternating circles of 5 perforated plates each. The uppermost circle is situated interradially and consists of large pentagonal or hexagonal pieces, the *basal* or *genital plates* (87—10); the largest of these, the *madreporite*, is a sievelike prominence (87—10). The plate lying next to the front and on the left side of the madreporite is the *anterior ocular* which lies on the upper end of the odd

Cenozoic regular echinoids of eastern United States: *JP* 15: 1–20, il, 1941; Cenozoic irregular echinoids of eastern United States: *JP* 16: 1–62, il, 1942. **Cooper, G. A.,** *Lepidechinoides*, a genus of Devonian echinoids: *JP* 5: 127–142, il, 1931; A new species of *Lepidesthes: AJS* (5) 22: 531–538, il, 1931. **Cotteau, G. H.,** Description des échinides fossiles de l'île Cuba: *Soc G Belgique*, An 9: 3–49, 1881. **Cotteau, G. H.,** and **Egozcue y Cía, J.,** Descripción de los equinoides fósile de la Isla de Cuba España: *Com Mapa Geol*, B 22: 1–99, 1897. **Deecke, W.,** Echinoidea jurassica: *Fos Cat*, pars 39: 1–540, 1929. **Duncan, P. M.,** Revision of the genera and great groups of the Echinoidea: *Linnean Soc (Zool)*, J 23, 1889. **Geis, H. L.,** Recent and fossil Pedicellariae: *JP* 10: 427–448, il, 1936. **Grant, U. S. IV,** and **Hertlein, L. G.,** The West American Cenozoic Echinoidea: *U Cal L A Pub, Math Phys Sc* 2: 1–225, pl 1–30, 1938. **Hawkins, H. L.,** Cretaceous Echinoidea from Jamaica: *G Mag* 60: 199–216, il, 1923; New collection of fossil Echinoidea from Jamaica: *G Mag* 61: 312–324, 1924. **Israelsky, M. C.,** New forms of west coast fossil Echinoidea: *U Cal Dp G*, B 14: 377–396, il, 1923; Echinoids from Tampico region, Mexico: *Cal Ac Sc*, Pr (4) 13: 137–145, 1924. **Jackson, R. T.,** Phylogeny of the Echini, with a revision of Paleozoic species: *Boston Soc N H*, M 7: 1–491, pl 1–76, 1912; Fossil Echini of the Panama Canal Zone and Costa Rica: *USNM*, Pr 53: 489–501, il, 1917; Fossil Echini of West Indies: *Carnegie Inst*, Pub 306: 1–103, il, 1922. **Kew, W. S. W.,** Tertiary echinoids of the Carrizo Creek region of the Colorado Desert: *U Cal Dp G*, B 8: 39–60, 1914; Tertiary echinoids from the San Pablo group of middle California: Idem, B 8: 365–376, 1915; Cretaceous and Cenozoic Echinoidea of Pacific Coast of North America: *U Cal Dp G*, B 12: 23–237, pl 1–42, 1920. **Klem, M. J.,** Revision of Paleozoic Palaeechinoidea, with synopsis of all known species: *Ac Sc St L*, Tr 14: 1–98, pl 1–6, 1904. **Lambert, J.,** Considérations sur les Échinides de la Commanche Série du Texas: *Soc Géol France*, B 26: 263–278, 1926; Quelques Échinides dans le Néogènes de l'est du Mexique: *Ec Geol Helvetiae* 21: 272–283, 1928; *Oligopygus*, et sur quelques Échinides fossiles de Cuba: *Soc Géol France*, B (5) 1: 289–304, 1931. **Sánchez, Roig M.,** Los equinodermos fossiles de Cuba: *Cuba, Dir Montes Minas, Bol Minas*, 10: 1–143, il, 1926. **Schuchert, C.,** Jackson on the phylogeny of the Echini [a review]: *AJS* (4) 34: 251–263, 1912. **Slocom, A. W.,** New echinoids from the Ripley group of Mississippi: *Field Mus N H*, Pub 134, gs 4: 1–16, il, 1909. **Smiser, J. S.,** Echinoid fragments in the Cretaceous rocks of Texas: *JP* 7: 123–163, il, 1933; Cretaceous echinoids from Trans-Pecos Texas. *JP* 10: 449–480, il, 1936. **Stefanini, G.,** Relations between American and European Tertiary echinoid faunas: *GSA*, B 35: 827–846, 1924. **Vaughan, T. W.,** Stratigraphic significance of species of West Indian fossil Echini: *Carnegie Inst*, Pub 306: 105–122, 1922. **Weisbord, N. E.,** Some Cretaceous and Tertiary echinoids from Cuba: *B Am Pal* 20: 1–270, il, 1934. **Whitney, F. L.,** The Echinoidea of the Buda limestone: *B Am Pal* 26: 1–36, il, 1916.

PLATE 85

[Figures are x1 unless otherwise indicated.]

1, 2. Dendraster gibbsi [USGS, M 54]. Top and side views. **3. Eoscutella coosensis** [U Cal Pub g s 12]. Upper surface of holotype. **4–9. Astrodaspis** spp. [U Cal Pub g s 12]. **4, 5. A. tumidus.** Side and top views of holotype. **6, 7. A. brewerianus.** Top and side views of holotype. **8, 9. A. spatiosus.** Top and side views of holotype. **10–12. Protoscutella mississippiensis** [USGS, M 54]. Side, bottom, and top of type. **13–15. Scutella aberti** (x0.3) [Md G S, Mioc]. Top, bottom, and side views. **16, 17. Dendraster excentricus** [U Cal L A, Pub Math Phys Sc 2]. Diagrammatic top and bottom views.

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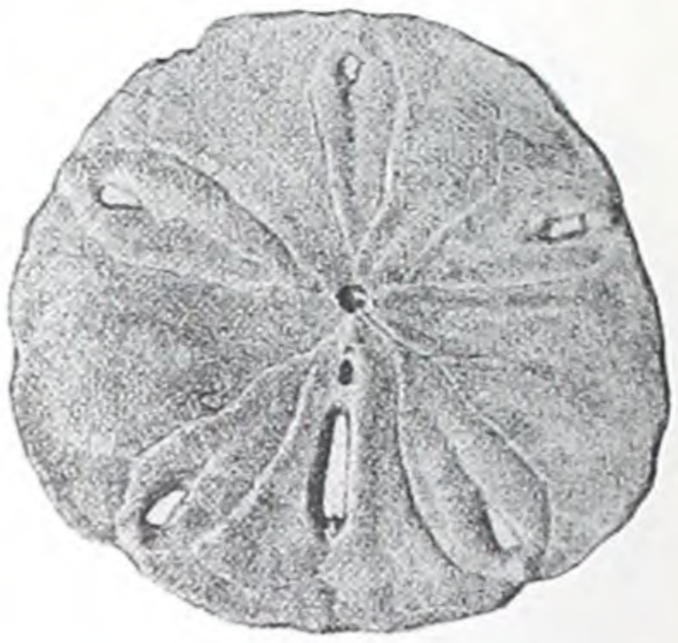

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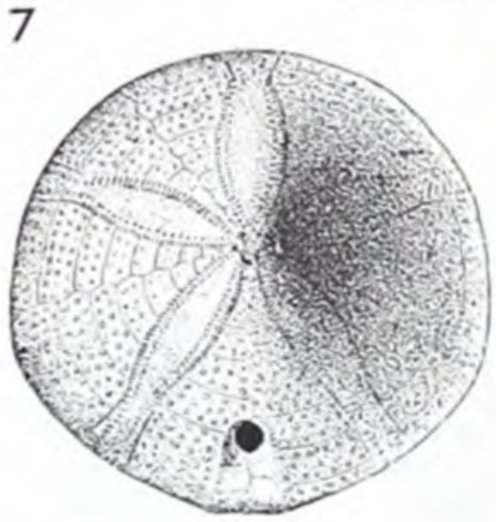

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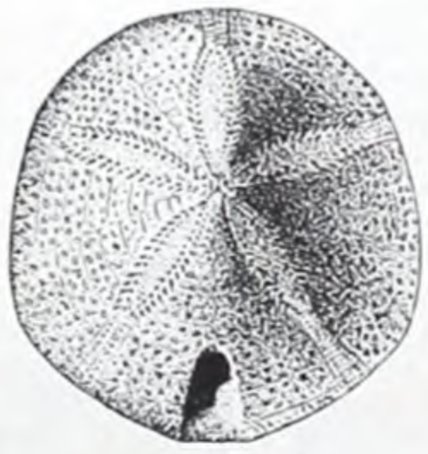

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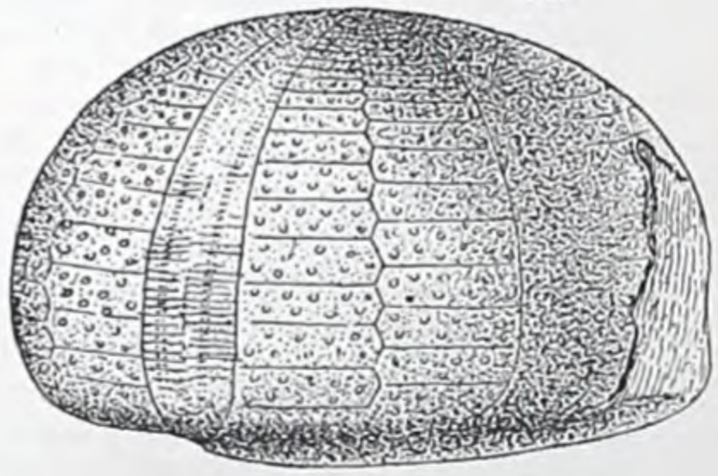

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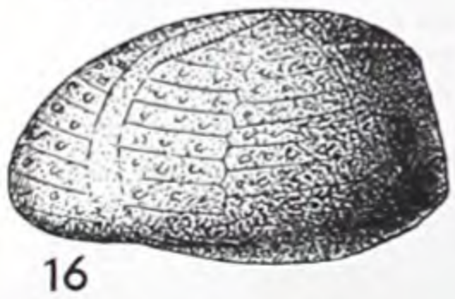

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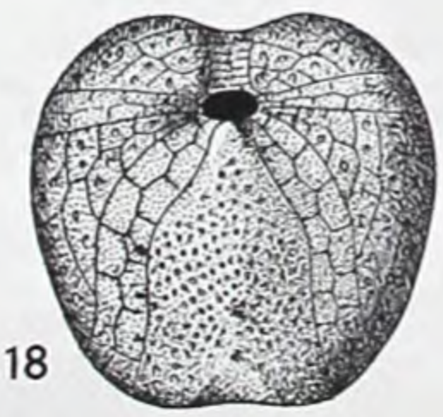

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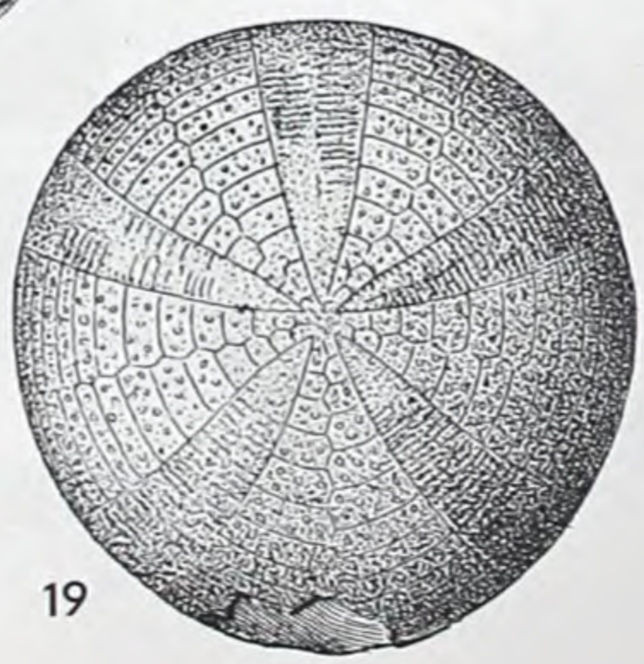

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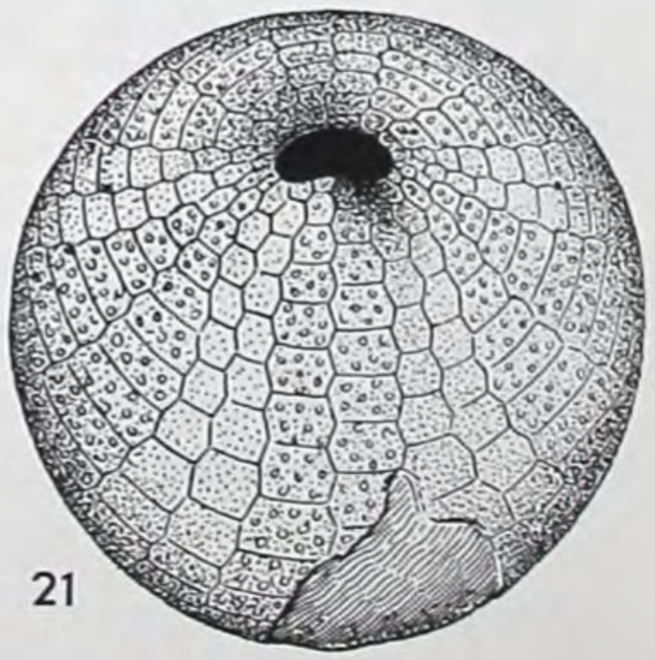

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or anterior *Amb*. The lower circle of smaller plates on the ends of the *Amb* are *radial* or *ocular plates* (87—10, 12).

Test plates usually are covered with *tubercles* and *granules* which carry *spines*. The larger tubercles are *primaries*. The base or boss of the tubercle supports a rounded knob (*mamelon*) which may be perforate (with a shallow central *foramen*) or imperforate. A plain sunken space surrounding the base of the tubercle is the *areola* (83—8); its outer limit generally is marked by a ring of granules, the *scrobicular circle*. All tubercles bear movable spines.

Fascioles are narrow bands of close granular ornamentation which support many small spines and *pedicellariae* (89), often appearing as shallow grooves on a bare test. The peripetalous fasciole follows the margin of the petaloid parts of the *Amb*. The *anal fasciole* surrounds the anus and the *subanal* incloses a space beneath the anus.

The vertical range of living echinoids is from low water, where they are often uncovered, to great depths (nearly 18,000 ft). Echinoid larvae are meroplanktonic.

Fossil echinoids range from **Ord.** to **Recent,** but are of little importance as index fossils until the **Cret.**

Order Perischoechinoida. Test regular (with periproct at center of upper side and peristome at center of lower); *Amb* with 2 to 20 columns of single plates; *IAmb* with 3 to 14. Order contains most of the Paleozoic echinoid genera. **Sil.–Perm.**

ECHINOCRINUS Agassiz 1841

(= ARCHAEOCIDARIS McCoy 1844, 1849; PALAEOCIDARIS Desor 1846)

(**Cidaris urii Fleming*). Test large, regular, and globular; *Amb* reaching the mouth, straight, with two columns of poriferous plates each with a pair of pores; plates irregular, imbricating toward mouth; *IAmb* with four to seven columns of large, thin plates, the median ones hexagonal, those bordering the *Amb* polygonal or rounded; median plates beveled slightly over those on either side and these over others to the *Amb* edge; each *IAmb* plate with a large primary tubercle on a conical elevation and surrounded by a large flat areola and a circlet of granules; primary spines large, usually serrated (the spines and single plates are frequently the only parts known). **Miss.–Penn.**

E. halliana (Geinitz) (82—13–15) *IAmb* plates small, up to 3 mm in diameter; primary spines slender, surface finely striate, the striae spinulose; length of spines about 7 mm. **Penn.:** Ia., Neb., Mo., Colo.

E. shumardiana (Hall) (82—6). **Miss.:** Keokuk and Warsaw of Ill., Mo., Nev.

E. agassizi (Hall) (82—1–3). Plates small, hexagonal except those adjacent to *Amb*; central tubercle slender, elongate, projecting above surrounding, abruptly elevated annulation; a low annular ridge outside this; spines elongate, compressed, contracted below, with greatest diameter one-third distance from base; spiniform tubercles except on lower part. **Miss.** (Burlington): Ia., Mo.; **Penn.:** Kan., Tex.

E. dininnii (White) (82—4, 5). Spines of several kinds; principal ones fusiform, from 50 to 60 mm long, with greatest diameter near middle, covered with many irregular spinules projecting at right angles and most abundant on lower part; smaller spines more slender, equally spinulose. **Penn.:** Ia., Mo., Neb.

E. aculeata (Shumard and Swallow) (82—7–12). Primary spine elongate, fusiform, with rather coarse, oblique spinules often curved at base and apex. **Penn.:** Mo., Tex.; **Perm.:** Kan.

OLIGOPORUS Meek and Worthen 1860

(= MELONOPSIS Meek and Worthen 1866)

(**Melonites danae*). Test spheroidal with more or less strongly developed melonlike ribs; *Amb* with four columns of plates and *IAmb* with four to nine at equator or ambitus (adult feature); differs from *Lovenechinus* in having isolated plates besides the four columns of *Amb* plates; pore-pairs multiserial. **Miss.**

***O. danae** (M and W) (82—17–19). **Keokuk:** Ind., Ill., Ia., Mo.

LOVENECHINUS Jackson 1912

(**Oligoporus missouriensis*). Four columns of plates in each *Amb*, pore-pairs biserial; four to seven columns of plates in each *IAmb*. **Miss.** (N. America; Europe).

***L. missouriensis** (Jackson) (82—20). **Burlington:** Mo.; **Keokuk:** Ill.

MELONECHINUS Meek and Worthen 1860

(= MELONITES Norwood and Owen 1846)

(**Melonites multipora* Norwood and Owen). Test large, spheroidal, grooved longitudinally; *Amb* broad, concave on both sides of a median ridge, with 6 to 12 columns of plates, each perforated near its outer border by a pair of pores; plates slightly imbricated, the median rows the largest; *IAmb* with 3 to 11

PLATE 86

[Figures are x1 and after Clark and Twitchell [USGS, M 54] unless otherwise indicated.]

1–3. Encope spp. 1, 2. E. macrophora (x0.9) [Tuomey and Holmes: Pleic Fos S Car 1857]. Side and top views. **3. E. micropora** [U Cal L A, Pub Math Phys Sc 2]. **4–6. Mellita caroliniana** (x0.9) [Tuomey and Holmes: Pleic Fos S Car 1857]. Side, top, and bottom views. **7–9. Cassidulus gouldii.** Three views of a specimen. **10–15. Hardouinia spp. 10–12. H. florealis.** Posterior, top, and bottom views. **13–15. H. aequoreus.** Side, bottom, and top views. **16–18. Enallaster texanus.** Three views of a specimen. **19–21. Holaster simplex.** Top, side, and bottom views.

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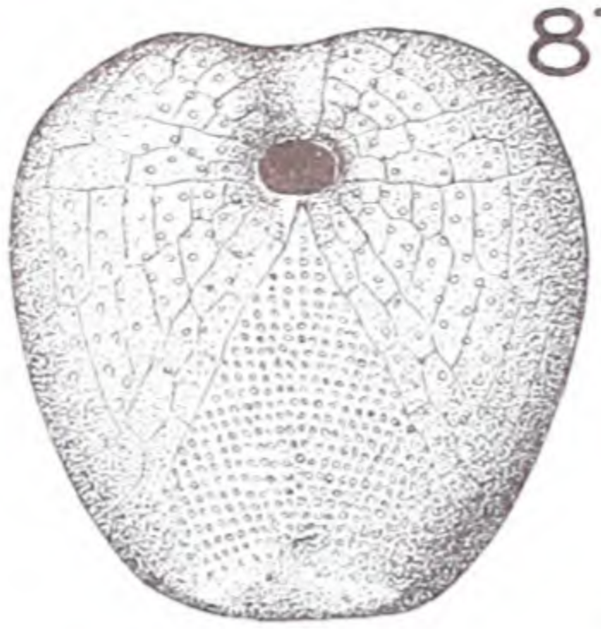

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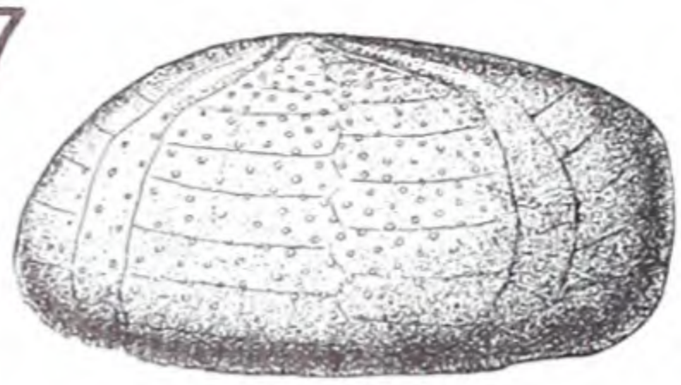

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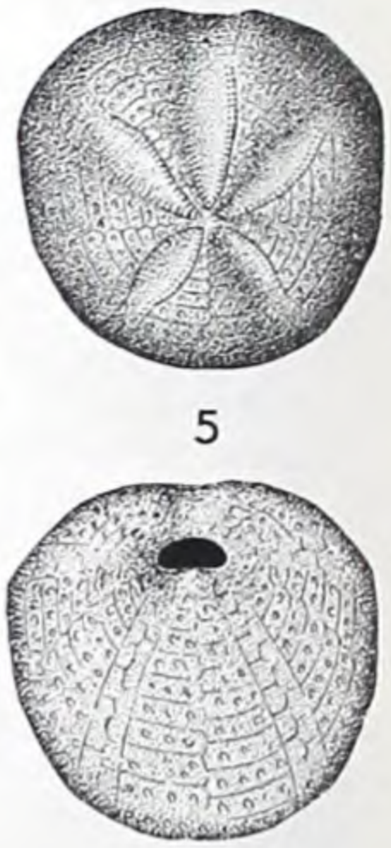

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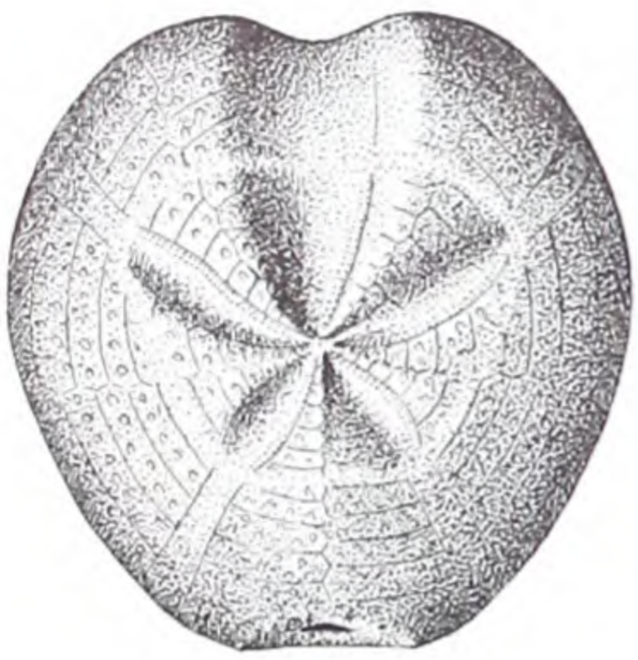

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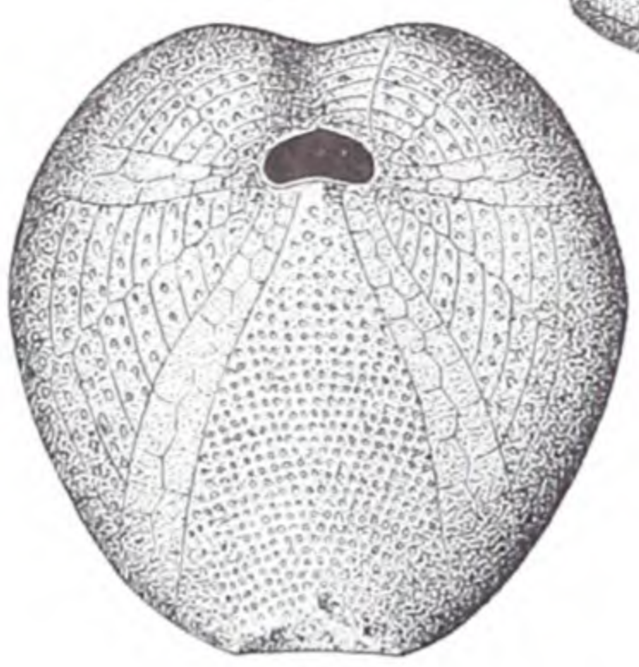

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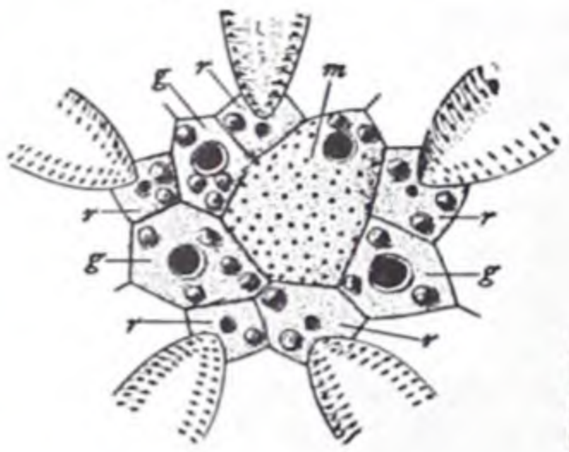

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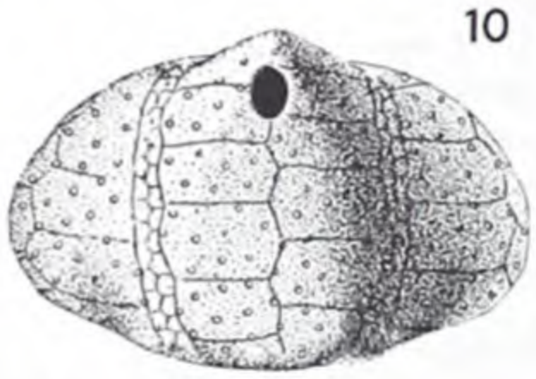

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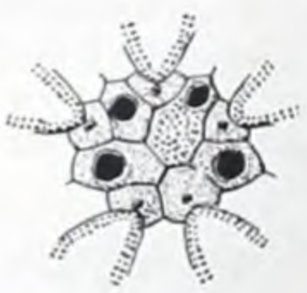

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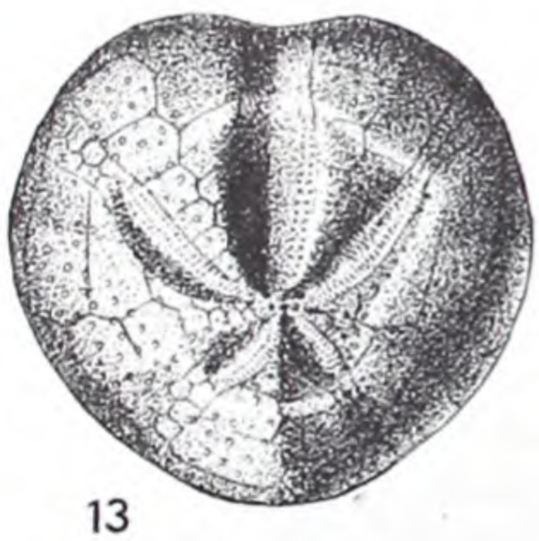

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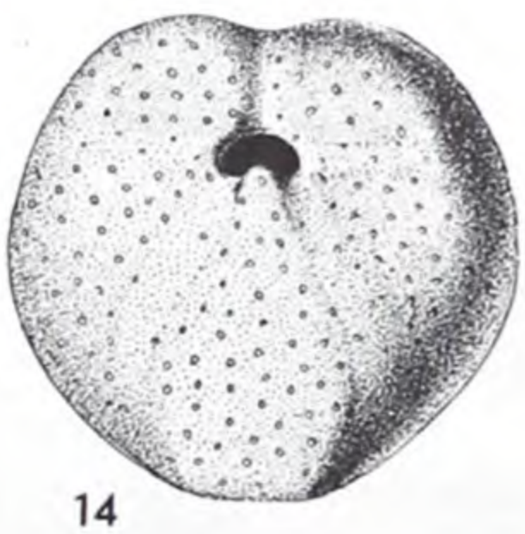

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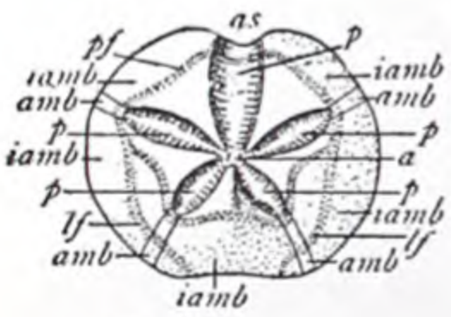

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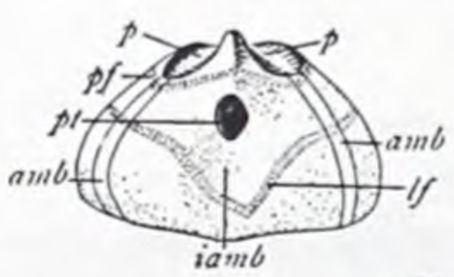

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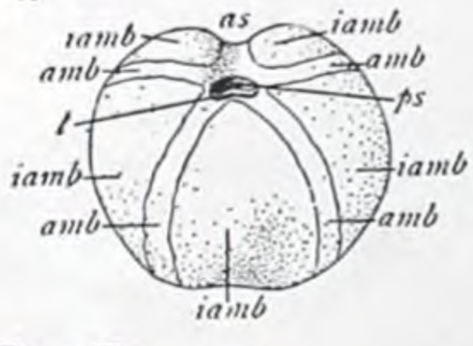

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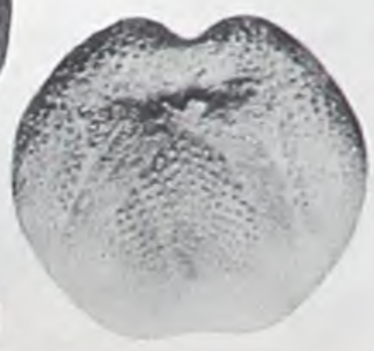

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columns of plates diminishing in number toward the poles; the median plates are hexagonal, the two rows adjacent to the *Amb* pentagonal, with edges indented by the zigzag of the *Amb* plates; edges of plates sometimes oblique, especially if thick; tubercles small, numerous; spines minute, very thin, needlelike; periproct circular; genital plates with three to five apertures each; oculars with a single pore; *IAmb* enter peristomial margin as two plates; passing dorsally new columns are introduced, the first plates of which are pentagonal with the most prominent apex pointing ventrally; a ventrally adjacent plate of one of the bounding columns is characteristically heptagonal; newly added plates dorsally are more or less rhombic in outline — a fact which facilitates orientation of obscure fragments. **Miss.** (N. America; Great Britain; Russia).

***M. multiporus** (N and O) (**83**—1–3). With 10 *Amb* and 7 to 9 *IAmb* columns of plates. **St. Louis:** Tenn., Mo.

LEPIDESTHES Meek and Worthen 1868

(**L. coreyi*). Characterized by great development of *Amb* and relative reduction of *IAmb*; plates of corona regular and imbricated; *IAmb* with three to seven columns of plates; *Amb* broad with 8 to 16 columns of plates. **Dev.–Penn.** (N. America; Great Britain; Russia).

***L. coreyi** M and W (**82**—16). **Miss.** (Keokuk): Ind.

Order Cidaroida. Test regular; *Amb* plates simple; primary tubercles perforate. **Miss.–Recent.**

CIDARIS Leske 1778

(**C. papillata* = *Echinus cidaris* Linnaeus. H. L. Clark (1907, 174) designated *Cidarites tribuloides* Lamarck). Test spheroidal; mouth opening central below, anus central above; *Amb* narrow, undulating, extending from top to bottom and composed of numerous plates; *IAmb* plates few, commonly with a simple primary spine. **U. Trias.–Recent.**

C. dilleri Clark (**83**—4). **U. Trias.:** Cal. (Hosselkus).

C. californicus Clark (**83**—5–7). **Jura:** Cal. (Mormon).

C. splendens (Morton) (**83**—12, 13). Differs from *Phyllacanthus mortoni* in having coarser sculpture and spindle-shaped spines. **Eoc.:** N. J. (Vincentown), Ala. (Salt Mt.).

DOROCIDARIS Agassiz 1869

(**D. papillata* Leske). Test almost spherical with subcircular peristome; apex dicyclic; suture depressed; *IAmb* tubercles perforate with deep scrobicula; *Amb* pores ovoid with pores of pair connected by a slight ridge; three to four knobs on an *Amb* plate; spines long, cylindrical, with rows of elevations. **Cret.–Recent.**

D. texanus (Clark) (**83**—8–11). Plates from ambital region: *Amb* plates 0.4 mm high, 2.5 mm wide; *IAmb*, 10.5 mm high, 15 mm wide. **L. Cret.** (Washita): Tex.

LEIOCIDARIS Desor 1855

(**L. imperialis* Lamarck). Test depressed, peristome small, apex dicyclic; *Amb* composed of equal, granulated primaries; pores connected by groove; *IAmb* plates large, their tubercles perforated; spines variable, generally cylindrical. **Cret.–Recent.**

L. hemigranosus (Shumard) (**83**—16; **89**—1–3). *Amb* areas with six rows of granules in middle; poriferous zones deeply depressed; one of the largest Mesozoic echinoids. **L. Cret.** (U. Washita): Okla., Tex.

PHYLLACANTHUS Brandt 1835

(**Ciderites imperialis* Lamarck). Differs from *Cidaris* in that pores of each pair are farther apart, horizontal, and connected by a groove. **Eoc.–Recent.**

P. mortoni (Conrad) (**83**—14, 15). **Eoc.** (Jackson): N. C., Ga., Fla., Ala.

Order Centrechinoida. Test regular; *Amb* plates compound, rarely simple; primary tubercles perforate or imperforate. **Trias.–Recent.**

SALENIA Gray 1835

(**Cidarites scutiger* Goldfuss). Test globose or depressed; *Amb* plates compound or largely simple; subanal plate touching all genitals; oculars exsert or ocular I reaching periproct, perforated at adoral edge. **Cret.–Recent.**

S. texana Credner (**89**—4, 5). **Cret.** (Fredericksburg and Washita): Tex.

PHYMOSOMA Archiac and Haime 1853
(= CYPHOSOMA Agassiz 1838)

(**Echinus milleri* Demarest = *Cidaris koenigi* Mantell). Test flattened, with very large peristome; tubercles crenulate, imperforate. **Cret., Tert.**

P. texanum (Roemer) (**83**—17–19; **89**—9). Pores uniserial from near peristome to ambitus, beyond which to apical system they are biserial; peristome about 0.4 diameter of test, with distinct branchial

PLATE 87

[Figures are x1 and after Clark and Twitchell [USGS, M 54] unless otherwise indicated.]

1–6. Eplaster spp. 1–3. E. whitei. Top, bottom, and side views of type. **4–6. E. californicus.** Side, top, and bottom views. **7–16. Hemiaster spp. 7–9. H. texanus.** Top, bottom, and side views. **10–12. H. slocomi (= H. lacunosus)** [Field Mus N H, Pub 134]. 10: Apical system (x7.5): **g**, genital plates; **m**, madreporite; **r**, radial plates. 11: Plates of anterior *Amb* (x6). 12. Portion of anterior *Amb* where it joins the apical system (x6). **13–16. H. parastatus.** Top, bottom, and posterior views, and apical system (x5) of type. **17–21. Linthia variabilis** [Field Mus N H, Pub 134]. 17–19: Three diagrammatic views; 20, 21: Top and bottom views of a specimen. **22–24. Eupatagus floridanus.** Bottom, side, and top views.

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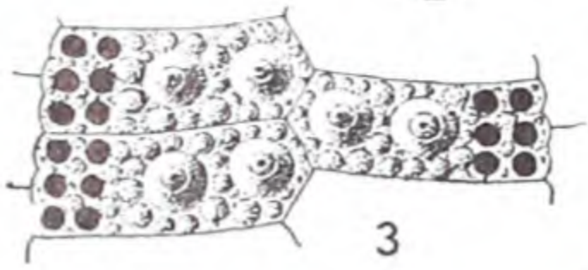
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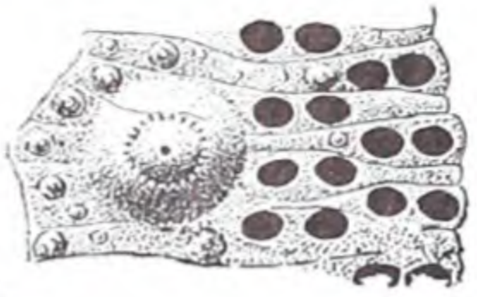
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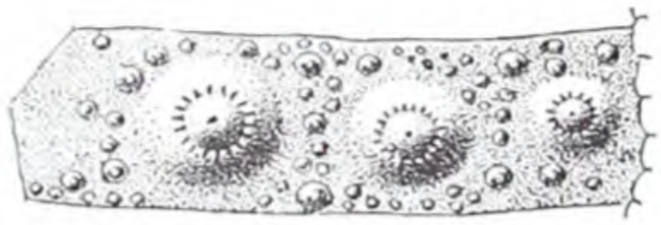

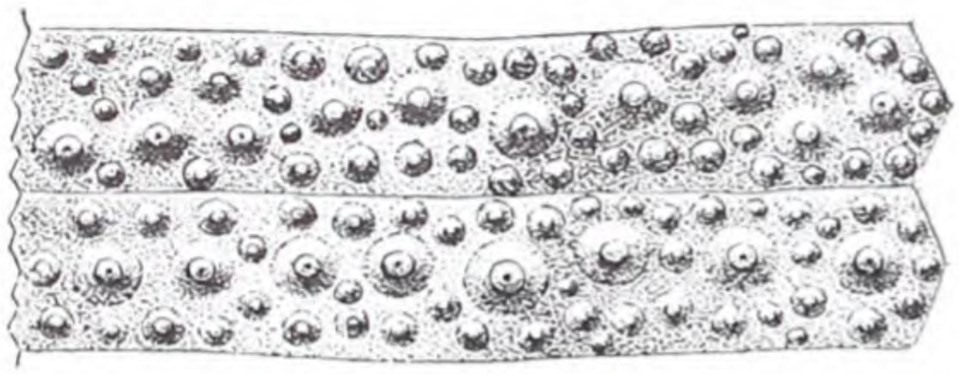

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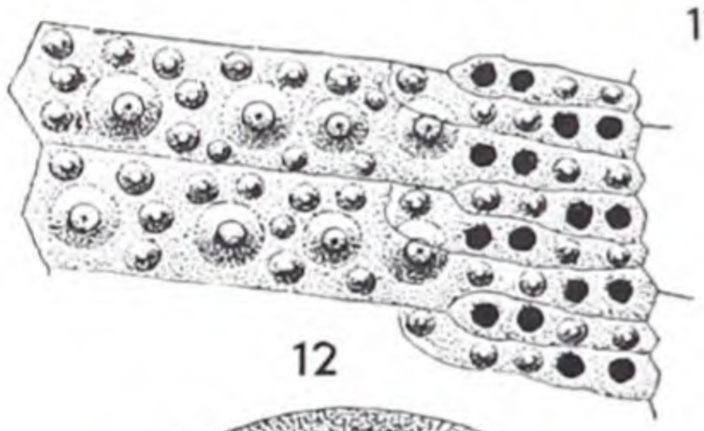
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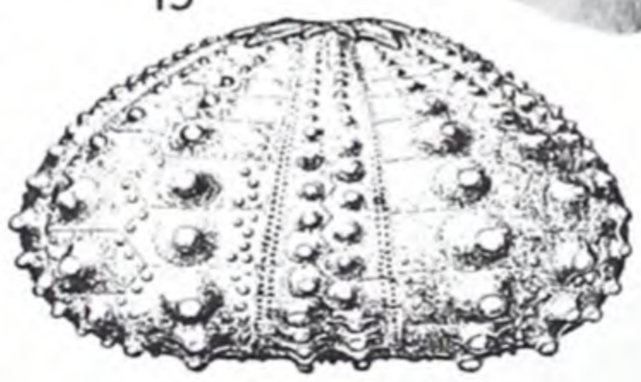
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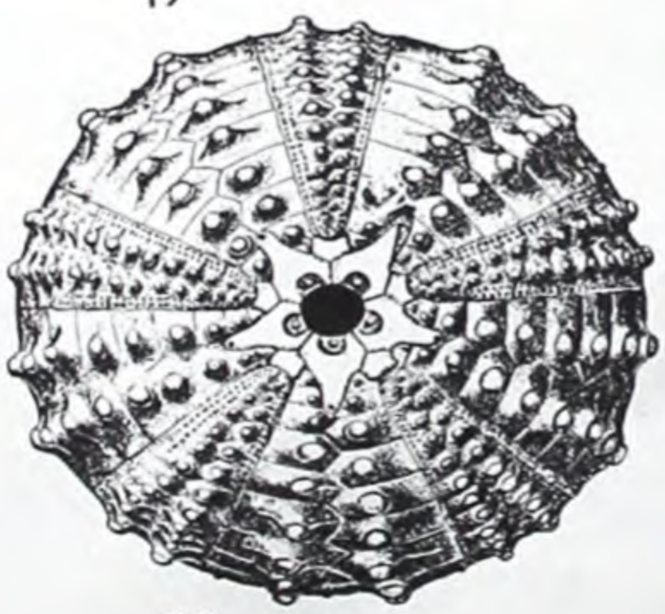
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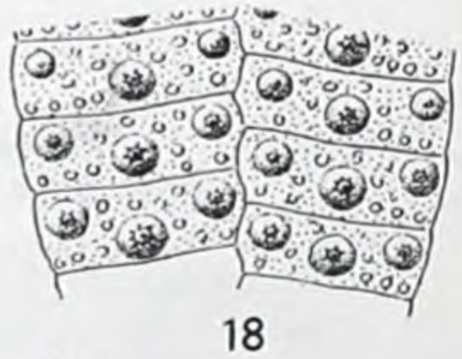
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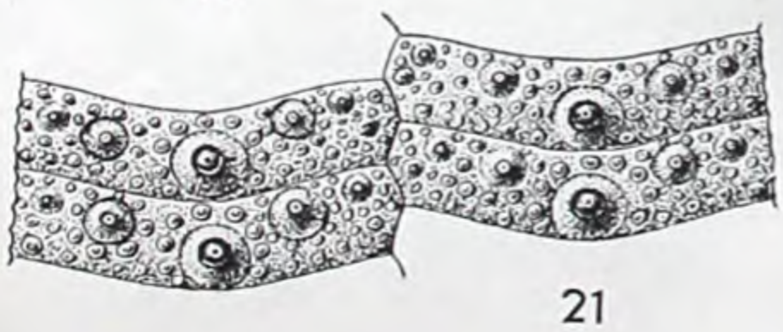
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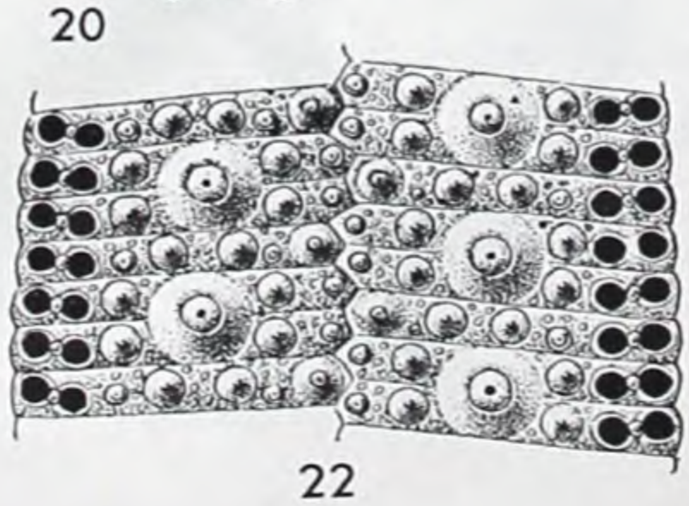
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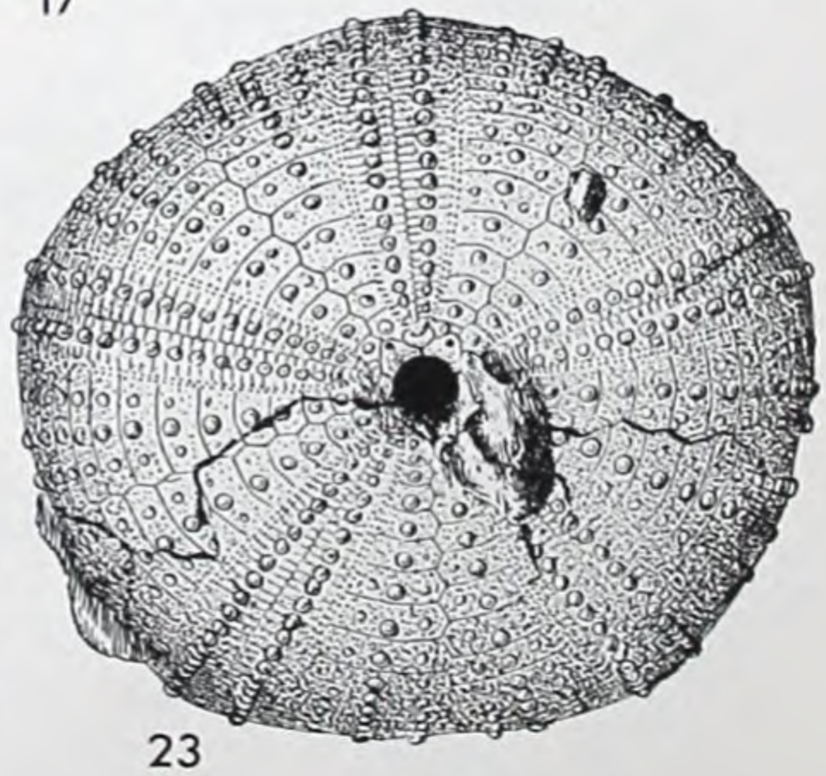
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incisions; periproct subpentagonal. **Fredericksburg:** Tex. (Comanche Peak, Goodland).

ARBACIA Gray 1835

(**Cidaris pustulosa* Leske). Primary spines short, cylindrical or flattened near tip; test stout; abactinal surface with numerous articulated primary spines; *Amb* plates with three pairs of pores. **Olig.–Recent.**

A. improcera (Conrad) (84—1–3). **U. Mioc.:** Va. (Yorktown).

PSAMMECHINUS Agassiz 1846

(**Echinus miliaris* Gmelin). *Amb* straight with narrow poriferous zones, interporiferous areas with two vertical rows of primary tubercles; *IAmb* with two vertical rows of primarie · and some secondaries and miliaries; peristome small, circular; buccal membane with numerous concentric plates besides 10 buccal plates. **Cret.–Recent.**

P. philanthropus (Conrad) (84—11–13). **U. Mioc.:** Va. (Yorktown).

Order Exocycloida. Test irregular. with more or less marked bilateral symmetry. **Jura.–Recent.**

HOLECTYPUS Agassiz 1842

(**Echinites depressus* Leske). *Amb* narrow, straight, widest at ambitus; some plates compound; *IAmb* with rather large plates and many rows of tubercles; mouth opening 10-angled; anal opening large, pyriform, situated between mouth and posterior edge of test; apical disk small, central. **Jura., Cret.**

H. planatus Roemer (84—4–9). *Amb* with six irregular rows of tubercles; pores in single pairs; *IAmb* with numerous narrow plates, each having a nearly horizontal row of small tubercles. (*H. charltoni* Cragin, from the Denton, is a much larger species.) **Fredericksburg** and **Washita:** Tex.

H. limitis Böse (90—5). Differentiated from preceding by its larger *Amb* and *IAmb* plates; former from ambitus average 3 mm or more wide, latter from same region, 6 mm or more wide. **U. Washita:** Tex.

CLYPEASTER Lamarck 1801

(**Echinus rosaceus* Linnaeus). Test roughly pentagonal, generally large, with central peristome and small marginal periproct; dorsal surface convex, high; *Amb* petaloid; ventral surface hollowed to deeply placed central peristome; ventral furrows straight; internal structure in form of pillars investing *Amb* with double wall but not forming concentric partitions near edges; surface with fine spines. **U. Eoc.–Recent.**

C. rogersi Morton (84—14–16). **Olig.** (Vicksburg): Ga., Ala., Miss.

C. bowersi Weaver (84—17, 18). **Plioc.:** Cal. (Carrizo); L. Cal., Mex.

***C. rosaceus** (Lamarck). Subelliptical, obscurely pentagonal; actinal surface often flat for a short distance before descending to deep peristome. **Plioc.?** of Florida; closely related forms are found in the **Tert.** of West Indies and San Domingo; living to depths of 30 ft off coast of S. C. to the Bahamas, Cuba, and Guadaloupe. There seems to be no important difference between Tertiary and Recent forms.

PERIARCHUS Conrad 1866

(**Sismondia alta* = *Scutella lyelli* Conrad). Scutelloid, with central apex abruptly elevated; margin thin; short *Amb* open at ends and extending only halfway to margin; genital pores five; periproct on under side, usually nearer to mouth than to margin. **Eoc., Olig.**

***P. lyelli** (Conrad) (84—19–21). Margin thin, gently concave for less than a fourth the diameter, rising abruptly in center to apical system; *Amb* uniform; actinal surface flat; grooves bifurcating. **Claiborne** and **Jackson:** N. C. (Castle Hayne), Ala. to Tex.

SCUTELLA Lamarck 1816

(**Echinodiscus subrotundus* Leske). Tests very flat, subcircular in outline, sometimes undulating or notched, broadest behind; *Amb* furrows branching; petaloid part of *Amb* unequal, well developed, nearly closed; peristome small, central, subcircular; periproct very small, mostly inframarginal; apical system central, more or less pentagonal **Mioc.–Recent.**

S. aberti Conrad (85—13–15). Discoidal, orbicular, very much depressed with three broad notches in posterior border; test swollen in middle and depressed at apex. **Mioc.:** Md. (Choptank).

PROTOSCUTELLA Stefanini 1924

(**Scutella mississippiensis* Twitchell). Characterized by five genital pores and bifurcated actinal furrows; differs from *Periarchus*, which it closely resembles, in having periproct at edge of notch in posterior region. **Eoc.**

***P. mississippiensis** (Twitchell) (85—10–12). **Claiborne:** Miss., Tex.

PLATE 88

[Figures are x1 and after Clark [USGS, M 54] unless otherwise indicated.]

1. Macraster elegans [U Tex B 2838]. **2–4. Cottaldia rotula.** Side view of the type; *Amb* plates (x10); *IAmb* plates (x10). **5–7. Tetragamma streeruwitzi.** *Amb* and *IAmb* plates (x8); top view of type. **8. Washitaster riovistae** (x2) [U Tex B 2838]. **9, 10. Macraster washitae.** Top and posterior views. **11–14. Micropedina symmetrica.** *IAmb* and *Amb* plates (x8); side and top views of type. **15–18. Leptarbacia arguta.** Top and side views of type; *Amb* plates (x15); *IAmb* plates (x4). **19, 20. Goniopygus zitteli.** Top and side views of type. **21–23. Orthopsis occidentalis.** *IAmb* plates (x3); *Amb* plates (x6); top view of type.

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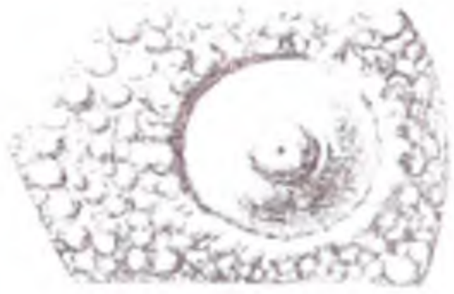

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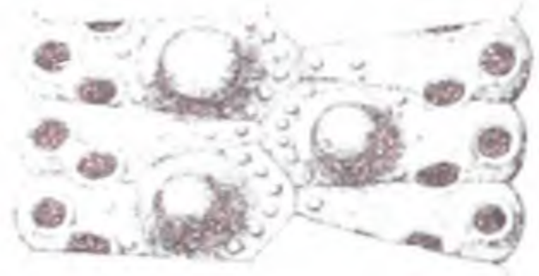

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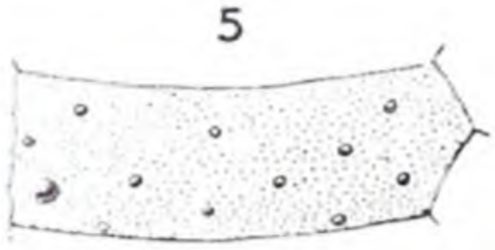

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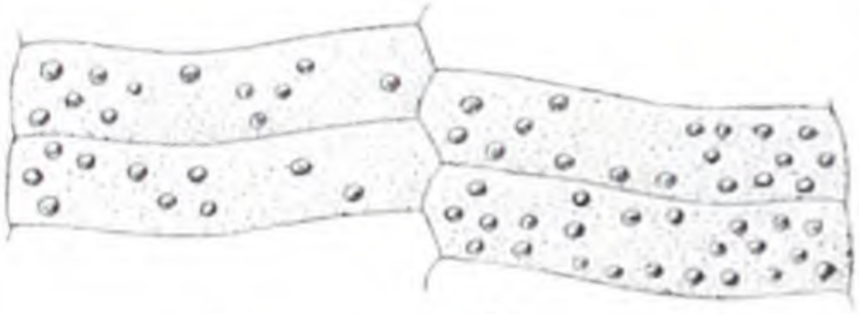

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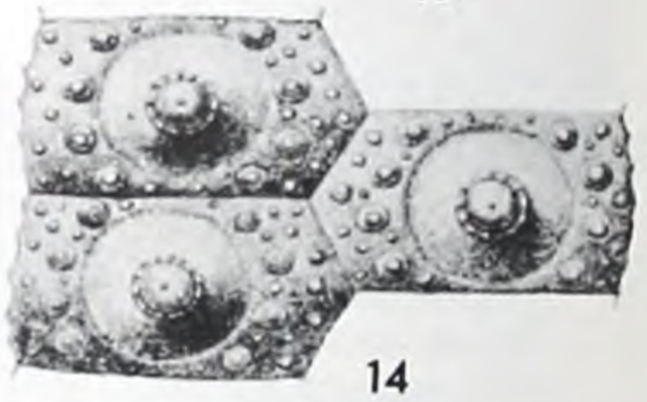

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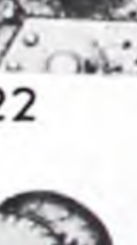

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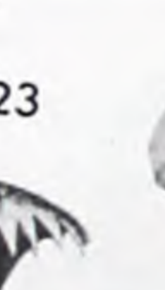

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ECHINARACHNIUS Gray 1825

(**Scutella parma* Lamarck). Test like *Scutella* but with petals open distally; petals nearly equal; periproct typically marginal; genital pores four. **Tert., Recent.**

E. fairbanksi (Arnold) (84—10). Anterior petal differs from others in having its inner row of pores diverging gradually to end, which is wide open—much more open than in the other petals. **Mioc.:** Cal. (Vaqueros).

DENDRASTER Agassiz 1847

(**Scutella excentrico* Eschscholtz). Test rather stout, wider than long, with abactinal system posterior to apex; no slits or lunules; posterior petals much shorter than others; periproct on oral surface. **Plioc., Recent.**

D. gibbsi (Rémond) (85—1-2). Apical system about one-fourth the longitudinal diameter from posterior end; *Amb* broad, the transverse grooves continued nearly to center; posterior petals flexuous; periproct submarginal. **Etchegoin:** Cal.

***D. excentricus** (Eschscholtz) (85—16, 17). Apical system eccentric, one-third diameter from posterior end; posterior pair of petals shortest, wide and nearly closed; summit in front of apical system. **Pleist., Recent:** Cal. (San Pedro); the common "sand dollar" on the Pacific Coast from Alaska to Mexico.

ENCOPE Agassiz 1840

(**Echinodiscus emarginatus* Leske). Larger and thicker than *Mellita* and with five instead of four genital pores; more or less subpentagonal, with broad notch or lunule in median line of two or more of the *Amb* and large lunule in posterior *IAmb*. **Mioc.–Recent.**

E. macrophora (Ravenel) (86—1, 2). Large; posterior lunule broad and surrounded by elevated rim; posterior end gently rounded, not notched; marginal notches shallow, posterior lateral pair deepest; periproct on proximal slope of posterior lunule; related to *E. grandis* Agassiz of **Plioc., Recent.** of Cal. **U. Mioc., Plioc.:** S. C. (Duplin), Fla. (Caloosahatchee).

E. micropora Agassiz (86—3). Test depressed, flattened; highest anteriorly; edges thin. **Plioc., Recent;** S. Cal. to Peru, S. A. and Galapagos.

EOSCUTELLA Grant and Hertlein 1938

(**Scutella coosensis* Kew). Test depressed, gently and uniformly arched, margin thin, much wider than long; *Amb* petals elongate and elliptical, with almost straight parallel sides, not completely closed at distal ends; apical system central; genital pores four; periproct small, marginal. **Eoc.**

***E. coosensis** (Kew) (85—3). **Tejon:** Ore.

MELLITA Agassiz 1841

(**Scutella quinquefora = Echinodiscus quinquies perforata* Leske). Test thin and flat as in *Scutella*, but with four or five *Amb* lunules; genital pores four; not an important index genus, but genotype is common along Atlantic Coast today. **Mioc.–Recent.**

M. caroliniana Ravenel (86—4-6). Slightly wider behind; posterior lunule twice as long as others. **U. Mioc.:** Va. (Yorktown), N. C., S. C. (Duplin).

ASTRODASPIS Conrad 1856

(**A. antiselli*). Test discoidal; apical system central or subcentral, with four genital pores; petals long, nearly straight, and open at distal ends; in later species petals are elevated and *IAmb* depressed; peristome approximately central; periproct marginal or inframarginal. **Mioc., Plioc.**

A. brewerianus Rémond (85—6, 7). **M. Mioc.:** Cal. (Briones).

A. tumidus Remond (85—4, 5). Test margin tumid, notched at ambitus in *Amb*, the notching deeper in the two posterior areas; petals elevated; *IAmb* usually with medial groove extending from margin to summit; mouth sunken. **U. Mioc.:** Cal. (San Pablo).

A. spatiosus Kew (85—8, 9). **L. Plioc.:** Cal. (Jacalitos).

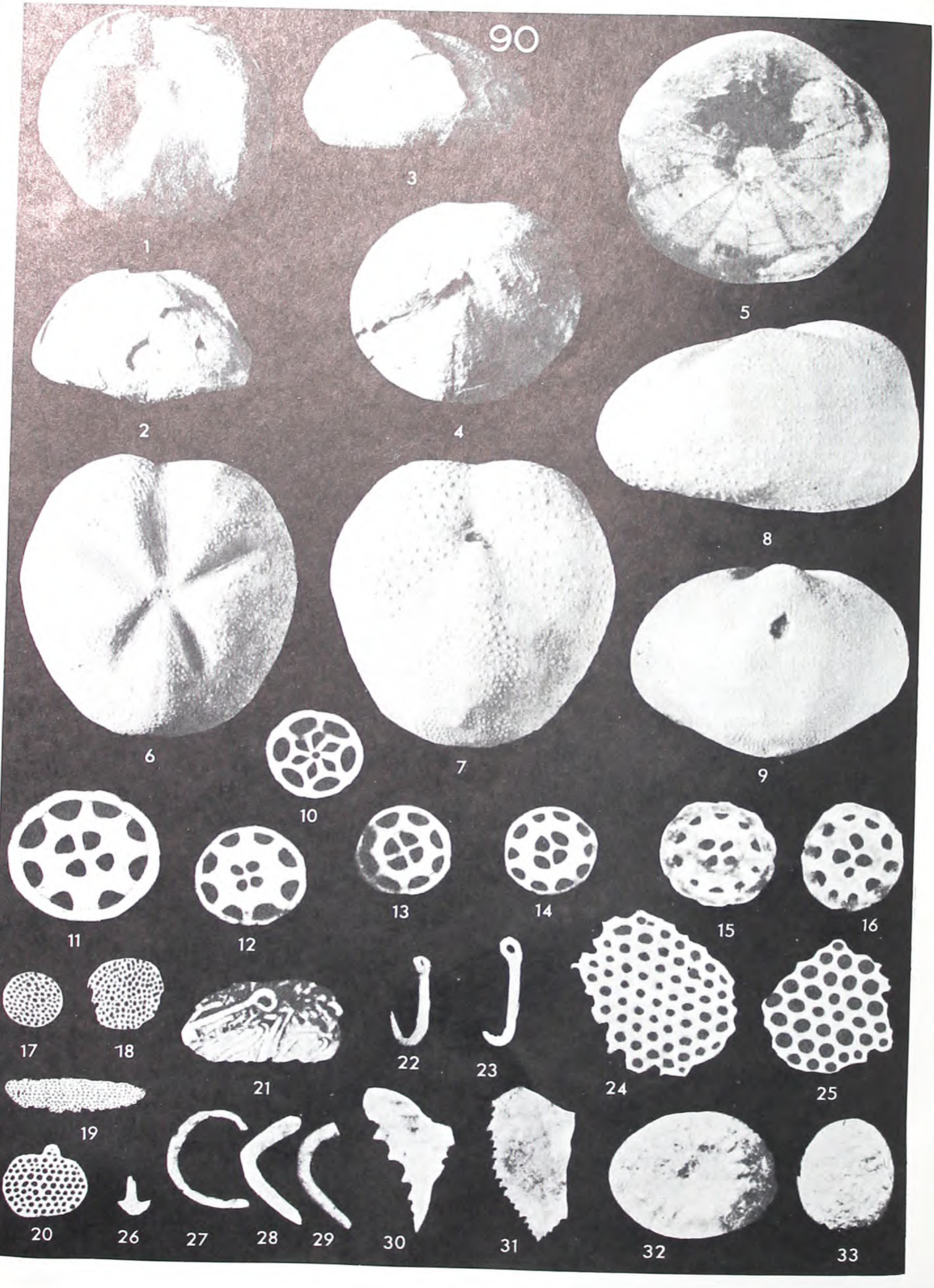
CASSIDULUS Lamarck 1801

(**C. caribaearum*). Test small, oblong, depressed

PLATE 89

[Figures are x1 unless otherwise indicated. Echinoid plates from USGS, M 54; pedicellariae from JP 10 [some of Geis' figures are from other authors] (*Amb* = Ambulacrum, ambulacral, etc.; *IAmb* = Interambulacrum, etc.).]

1–3. Leiocidaris hemigranosus. Tubercles (x2); *IAmb* plate (x2); portion of *Amb* (x5). **4, 5. Salenia texana.** Portion of *Amb* (x10); *IAmb* (x3). **6. Eplaster whitei.** Portion of *Amb* (x8). **7, 8. Hemiaster calvini.** *IAmb* plate (x3); anterior *Amb* plates (x5). **9. Phymosoma texanum.** Portion of *IAmb* (x3). **10–12. Holaster simplex.** Tubercle (x10); *Amb* plates (x3); *IAmb* plate (x3). **13, 14. Loriolia texana.** *Amb* plates (x8); *IAmb* plates (x8). **15, 16. Macraster nodopyga.** *IAmb* and *Amb* plates (x5). **17–19. Loriolia ornata.** *Amb* and *IAmb* plates (x10) and tubercle (x20). **20, 21. Enallaster texanus.** *Amb* plates (x10). **22, 23. Goniopygus zitteli.** *Amb* and *IAmb* plates (x3, x4). **24–45. Pedicellariae. 24–29. Globiferous pedicellariae. 24.** **Sphaerechinus granularis** (Lamarck) (x10). **Recent.** 25–27: Proximal and two side views of a head (x40), from **U. Miss.** of Mo. (Glen Dean). 28, 29: Exterior and interior of a valve (x25) from **Penn.** of Ill. (La Salle). **30–35. Ophicephalous pedicellariae. 30–32. Pourtalesia wandeli** Mortensen [after Mortensen]. Complete head (x65) and side view and inner face of valve (x110); **Recent.** 33–35: Complete head (x40) and interior and exterior of valve (x40), from **Penn.** of Tex. (Graham). **36, 37. Triphyllous pedicellariae. 36. Araeosoma bicolor** Agassiz and Clark (x55) [after Agassiz and Clark]. **Recent. 37. Aspidodiadema tonsum** Agassiz (x55) [after Agassiz and Clark]. **Recent. 38–44. Tridentate pedicellariae.** 38–40: Exterior and interior of valve (x25) and proximal end of complete head (x25), from **Penn.** of Tex. (Mineral Wells). **41, 42. Eucidaris thouarsi** (Valentin) [after Mortensen]. Closed head (x33) and side view of single valve (x45). **Recent.** 43, 44: Side views of a head (x40) from **U. Miss.** of Ill. (Renault). **45. Echinus sphaera** (Forbes) [after Geddes and Beddard: R Soc Edinburgh, Tr 30]. Plates, spines, and pedicellariae (x20). *a*, triphyllous; *b*, globiferous; *c*, ophicephalous; *d*, tridentate. **Recent.**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convex dorsally, flat below; *Amb* narrow, subpetaloid, not closing; pores continuing around margin to well developed floscelle; mouth in front of middle; periproct longitudinally elongated, on upper posterior margin. **Tert., Recent.**

C. gouldii (Bouvé) (86—7–9). **Vicksburg:** Fla. (Suwanee), Ga. (Flint River).

HARDOUINIA Archiac and Haime 1853

(**Pygorhynchus mortonis* Michelin = *Cassidulus subquadratus* Conrad). Includes Cretaceous species originally assigned to *Cassidulus*. **Cret.**

H. florealis (Morton) (86—10–12). Marginal outline subpentagonal, angular posteriorly; apex slightly in front of center; *IAmb* wide, covered with small, perforated tubercles; peristome pentagonal, with *Amb* areas near it broadened and conspicuous; periproct in a short, narrow furrow. **U. Cret.:** N. J., Del., Ala. (Ripley).

H. aequoreus (Morton) (86—13–15). Differs from preceding in its more depressed and elongated form. **U. Cret.:** N. J., Ala.

HOLASTER Agassiz 1835

(**H. nodulosus* Goldfuss). Test oval in marginal outline, flat beneath, swollen and high above; plates large; anterior *Amb* in a shallow groove; mouth opening subanterior, elliptical, broadest transversely; anal opening situated above lower posterior margin, oval; apical system elongate. **L. Cret.–Tert.**

H. simplex Shumard (86—19–21; 89—10–12). Test much elevated, rounded above, flattened below; plates commonly found. **L. Cret.:** Okla., Tex. (Duck Creek, Fort Worth, Weno).

HEMIASTER Desor 1847

(**Spatangus bufo* Brongniart). Test heart-shaped, longer than broad, depressed, with numerous plates and an anterior groove; the two posterior *Amb* meet close together and are separated from the three anterior by a wide space; anterior *Amb* lies in shallow groove; pores oblique and in pairs on each side; anterolateral *Amb* diverge, are dorsally sunken, petaloid, and much longer than the posterolateral; pores of petaloid portion united, the outer usually largest; fasciole present near edge of test, surrounding the petaloid parts. **Cret.–Recent.**

H. texanus Roemer (87—7–9). Anterior groove broad and deep; anterolateral *Amb* bent backward in upper portion; mouth opening large, transversely oval; anal opening large, oval, at center of truncated posterior surface. **U. Cret.:** Tex. (Austin).

H. slocomi Lambert (= **H. lacunosus** Slocom) (87—10–12). Differs from preceding in its smaller size and in the sunken areoles around the tubercles; posterior *IAmb* area rounded (forms a ridge in *H. parastatus*). **U. Cret.:** Tenn.?, Miss. (Prairie Bluff).

H. parastatus (Morton) (87—13–16). Upper surface elevated, with a deep anterior groove and sharp posterior ridge, the latter truncated by flat, nearly vertical posterior margin; petaloid areas depressed, anterior pair bent backward at their center and about twice length of posterior; mouth opening with distinct overhanging lip; anal opening small, situated high on truncated posterior surface. **U. Cret.–Eoc.:** Ripley of N. J., Ala., Miss.; Rancocas (Vincentown) of N. J.

EPIASTER Orbigny 1855

(**E. trigonalis* Desor). Test heart-shaped, notched by anterior groove with posterior keel; unpaired *Amb* with rounded pores separated by granules; peristome labiated; no distinct fasciole. **Cret.**

E. whitei (Clark) (87—1–3; 89—6). Small; anal opening high on posterior truncated surface. **L. Washita** and **U. Fredericksburg:** Tex.

E. californicus (Clark) (87—4–6). Test small, depressed, subquadrate in outline, with feeble groove in center of anterior margin. **U. Cret.:** Cal. (Chico).

MACRASTER Roemer 1888

(**M. texanus*). Cordiform, paired *Amb* wide and straight; unpaired *Amb* with pores *en chevron*, at least in maturity; some individuals show traces of a peripetalous pseudofasciole, which is more or less diffuse. **Cret.**

M. washitae Lambert (88—9–10). No fasciole; pores of unpaired *Amb* transverse; paired *Amb* short, located in rather deep grooves. **Washita:** Tex. (Ft. Worth?).

M. elegans (Shumard) (88—1). Large; sparsely granulated; test rounded posteriorly; *Amb* longer than in related species. **Washita:** Tex. (Duck Creek, Ft. Worth).

M. nodopyga Lambert (89—15–16). *Amb* short; posterior truncated area bordered with vertical rows of prominent granules. **Washita:** Tex. (Ft. Worth).

ENALLASTER Orbigny 1853
(= HETERASTER Orbigny 1853; ENNALASTER Agassiz 1872)

(**Heteraster orbignyi* [author undetermined]). Test heart-shaped, longer than broad, with anterior

PLATE 90

1–4. Macropneustes mortoni (x0.5) [USGS, M 54]. Four views of a crushed specimen. **5. Holectypus limitis** [U Tex B 2838]. Top view of an imperfect specimen (x1). **6–9. Micraster (Plesiaster) americanus** (x2) [U Tex B 4101; photographs furnished by L. W. Stephenson]. Top, bottom, side, and posterior views. **10–33.** Holothurian elements [JP 6 unless otherwise indicated]. **10. Paleochiridota plummerae** (x50). **11–16. Protocaudina** spp. **11–13. P. traquairii** (x100, x50, x50). **14–16. P. kansasensis** [JP 4]. 14: Specimen (x75). 15, 16: Specimens (x60). **17–25. Ancistrum** spp. 17–20: (x25); 24 and 25: (x60); all *Ancistrum*?, several species. **21. A. ludwigi** (x25). **22, 23. A. brownwoodensis** (25). 26–33: Bodies of several types (x25).

groove; petaloid parts of anterolateral *Amb* divergent, flexuous, tending to close, and with very unequal poriferous zones, of which the posterior are the larger; pairs of pores oblique; posterolateral *Amb* short, divergent; mouth opening wide, with lip; anal opening in truncated posterior surface. **Cret.**

E. texanus (Roemer) (**86**—16–18; **89**—20, 21). Test broad in anterior portion; anterior groove deep; upper surface convex, elevated; base flat, depressed at mouth opening; *Amb* narrow, unequal, posterolateral pair much shorter than others; anal opening high on posterior margin. **L. Cret.:** Tex. (Trinity, Washita), N. Mex.; Mexico.

WASHITASTER Lambert 1926
(= WASHISTATER Lambert 1926)

(**Hemiaster riovistae* Adkins). Differs from *Enallaster* in having a very large, multiple peripetalous fasciole. **Cret.**

***W. riovistae** (Adkins) (**88**—8). **Weno.:** Tex.

LINTHIA Desor 1853

(**L. insignis* Mérian = *Escheria insignis* Merian). Anterior *Amb* in deep groove; pores round, small, in pairs on each side; anterolateral *Amb* longer than posterior pair; petals sunk in grooves, pores joined; peripetalous and lateral (but no subanal) fascioles present. **Cret.–Plioc.**

L. variabilis Slocom (**87**—17–21). **U. Cret.** (Ripley): N. C. (Peedee), Miss. (Prairie Bluff, Owl Creek), Tex. (Navarro).

MICRASTER Agassiz 1836

(**Spatangus coranguinum* Klein). Cordiform, tumid, rather depressed; anterior *Amb* apetaloid, in shallow depression; anterolateral *Amb* subpetaloid dorsally, diverging; posterolateral shorter than others with elongated, conjugated pores; periproct supramarginal; apical system eccentric in front; broad subanal fasciole. (The subgenus PLESIASTER Pomel 1778 (**Micraster peinei* Coquand) differs from typical *Micraster* in possessing a peripetalous fasciole besides the characteristic subanal fasciole). **Cret.–Mioc.**

M. (**Plesiaster**) **americanus** Stephenson (**90**—6–9.) **U. Cret.:** ?Ala. (Prairie Bluff), Tex. (Navarro).

EUPATAGUS Agassiz and Desor 1847

(**E. valenciennesii*). Petals short, flush, terminated by peripetalous fasciole; posterior petals as wide near rounded tips as medially; *Amb* III not depressed. **Tert., Recent.**

E. floridanus Clark (**87**—22–24). **Olig.:** Fla. (Vicksburg)

MACROPNEUSTES Agassiz 1847

(**Micraster deshayesi*). Test large, thick, cordiform; petals elongate or broad, grooved or semi-flush, open or imperfectly closed; poriferous areas of equal widht with the interporiferous. **Eoc.–Recent.**

M. mortoni (Conrad) (**90**—1–4). **U. Eoc.** (Jackson), **L. Olig.** (Vicksburg): Ga., Ala.

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Isolated Plates. The importance of echinoid plates for zoning and correlation has been pointed out by Smiser (1931, 356; 1933, 123–163), who has zoned the Texas Lower Cretaceous on the basis of fragmental echinoid remains. The more important species identified by him are listed hereafter.

Trinity. **Loriolia texana** (Clark) [**89**—13, 14].

Fredericksburg. **Salenia texana** Credner [**89**—4, 5]; **Phymosoma texanum** (Roemer) [**83**—17–19; **89**—9]; **Goniopygus zitteli** Clark [**88**—19, 20; **89**—22, 23]; **Holectypus planatus** Giebel [**84**—4–9]; **Enallaster texanus** (Roemer) [**86**—16–18; **89**—20, 21]; **Epiaster whitei** (Clark) [**87**—1–3; **89**—6].

Washita. **Dorocidaris texanus** (Clark) [**83**—8–11]; **Leiocidaris hemigranosus** (Shumard) [**83**—16; **89**—1–3]; **Loriolia ornata** (Clark) [**89**—17–19]; **Micropedina symmetrica** (Cragin) [**88**—11–14]; **Tetragamma streeruwitzi** (Cragin) [**88**—5–7]; **Leptarbacia arguta** Clark [**88**—15–18]; **Orthopsis occidentalis** Cragin [**88**—21, 23]; **Salenia texana** Credner [**89**—4, 5]; **Cottaldia rotula** Clark [**88**—2–4]; **Holectypus limitis** Böse [**90**—5]; **Holaster simplex** Shumard [**86**—19–21; **89**—10–12]; **Enallaster texanus** (Roemer) [**86**—16–18; **89**—20, 21]; **Washitaster riovistae** (Adkins) [**88**—8]; **Macraster elegans** (Shumard) [**88**—1]; **Macraster nodopyga** Lambert [**89**—15, 16]; **Macraster washitae** Lambert [**88**—9, 10]; **Epiaster whitei** (Clark) [**87**—1–3; **89**—6]; **Hemiaster calvini** Clark [**89**—7, 8].

Pedicellariae. Geis (1936, 427–448) recently has brought together all known information on fossil Pedicellariae and has pointed out that these fragments may prove of considerable value as guide fossils.

Pedicellariae are minute, protective or cleansing organs articulated upon granules and scattered between the spines over the entire test in echinoids and asteroids [**89**—24–45]. The head consists of two to five more or less equal calcareous valves which are opened and closed by muscles. In echinoids the head typically is attached directly or by a muscular neck to a calcareous stalk, and this in turn is attached by muscles to a small granule on the test. Four major types of pedicellariae are generally recognized:

(1) *Globiferous* Pedicellariae have been found in Mississippian [**89**—25–27] and Pennsylvanian [**89**—

28, 29] rocks, and are common on living echinoids [89—24].

(2) *Tridentate* Pedicellariae have been reported from the same horizons as (1) [89—38–40; 43, 44; and Recent forms, 41, 42].

(3) *Ophicephalous* Pedicellariae have been reported from Pennsylvanian rocks [89—33–35] and may be expected in rocks from that age to Recent. [89—30–32].

(4) *Triphyllous* Pedicellariae [89—36, 37].

Very little is known about the relation of fossil Pedicellariae to described echinoid species. The Pedicellariae of living echinoids are sensitive and variable and it is possible that fossil forms may be likewise, in which case they might be of considerable value as guide fossils. They should be looked for especially in rocks which contain other fragmental echinodermal material.

CLASS HOLOTHUROIDEA[1]

Holothurians differ strikingly from all other echinoderms in the form of the body and nature of the skeleton. The animal is an elongated body with the anus typically at one end and the tentacle-encircled mouth at the other. The skeleton consists of numerous calcareous elements, of microscopic or near-microscopic size, which stud the leathery integument and lie also in various organs of the body. They exhibit wide variation in size, shape, and structure and may unite to form a very delicate skeleton (90—10–33).

The simplest of the elements are tiny, irregular grains (*miliary granules*). *Supporting rods* are small, curved or straight spicular bodies which lie in the tentacles and in other parts of the body. *Rosettes*, irregular branched particles, lie in the body wall; these are designated *plates* if they are perforated disks. A plate with a definite projection rising from its midpoint is a *table*, which itself consists of a basal disk and a projecting *spire*. Other elements have the shape of hooks, wheels, anchors, cups, etc., and are named after the object they resemble. Besides the elements so far described, all of which lie in the body wall, tentacles, or tube feet, there may be plates around the anal opening (the five anal teeth) and around the esophagus (the dental ring, consisting of five radial and five interradial plates).

The calcareous elements are the only part of the animal likely to be preserved in most instances, but mud fillings and impressions of the soft body and castings similar to those of some worms have been reported. The first holothurians appeared in the **Cambrian** and they have left a sparse fossil record scattered through the geologic column to **Recent** sediments.

[1] **Clark, A. H.,** Cambrian holothurians: *Am Nat* 47: 488–507, 1913. **Clark, H. L.,** Fossil holothurians: *Science* ns 35: 274–278, 1912. **Croneis, C.,** and **McCormack, J.,** Fossil Holothuroidea: *JP* 6: 111–148, pl 15–21, 1932.

PROTOCAUDINA Croneis 1932

(**Cheirodata traquairii* Etheridge). Calcareous, concavo-convex disks with 4 central holes and 8 to 10 outer perforations; rim circular or slightly scalloped. **Miss.–Perm.** (U. S. A.; Europe).

***P. traquairii** (Etheridge) (**90**—11–13). **Chester:** Ill.

P. kansasensis (Hanna) (**90**—14–16). Ten outer perforations. **Penn.:** Kan. (Elmdale, Burlingame, Chase), Tex. (Graford, Mineral Wells).

PALEOCHIRIDOTA Croneis 1932

(**P. plummerae*). Calcareous, concavo-convex disks with six outer spokes and a variety of ornamental perforations or markings in central area; rim circular or scalloped. **Penn., ?Mesozoic,** and **Cenozoic** of Europe.

***P. plummerae** Croneis (**90**—10). **Penn.:** Tex. (Mineral Wells).

ANCISTRUM Etheridge 1881

(= ACHISTRUM Etheridge 1881)

(**Achistrum nicholsoni*). Skeletal elements are perforated plates of irregular oval form and anchorlike spicules, all of very small size. **Miss.–Tert.**

A. ludwigi Croneis (**90**—21) and **A. brownwoodensis** Croneis (**90**—22, 23). **Penn.:** Tex. (Brownwood).

Ancistrum? sp. (**90**—17–20, 24, 25). Numerous elements which probably belong to *Ancistrum* have been reported from the **Miss.** and **Penn.** of Ill. and Tex. These are associated with several kinds of spicules which are also considered holothuroidal.

groove; petaloid parts of anterolateral *Amb* divergent, flexuous, tending to close, and with very unequal poriferous zones, of which the posterior are the larger; pairs of pores oblique; posterolateral *Amb* short, divergent; mouth opening wide, with lip; anal opening in truncated posterior surface. **Cret.**

E. texanus (Roemer) (**86**—16–18; **89**—20, 21). Test broad in anterior portion; anterior groove deep; upper surface convex, elevated; base flat, depressed at mouth opening; *Amb* narrow, unequal, posterolateral pair much shorter than others; anal opening high on posterior margin. **L. Cret.:** Tex. (Trinity, Washita), N. Mex.; Mexico.

WASHITASTER Lambert 1926
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CHAPTER VI

WORMS[1,2]

"Worms" as here used comprise a heterogeneous group of elongate organisms which have been classified in the following phyla, only the last of which has an appreciable fossil record. (Phyla or smaller divisions which lack any fossil record or which have a very sparse one are indicated by an *.)

PHYLUM *PLATYHELMINTHES

PHYLUM *NEMATHELMINTHES

PHYLUM *TROCHELMINTHES

PHYLUM ANNELIDA (ANNULATA)

Class **Chaetopoda** (segments and legs covered by chitinous setae)
Subclass **Polychaeta**
Order ***Archichaetopoda**
Order **Phanerocephala**
Order **Cryptocephala**
Order ***Miskoa**
Subclass ***Oligochaeta**
Subclass ***Myzostomida**
Subclass ***Echiurida**
Class **Sipunculoidea**
Class ***Archiannelida**
Class ***Hirudinea**

PHYLUM ANNELIDA (ANNULATA)

Worms of this phylum are elongated, segmented, bilaterally symmetrical animals with a mouth at one end and an anal opening at the other. They are equipped with silico-chitinous jaws (*scolecodonts*) which are frequently preserved as black, highly lustrous bodies that are unaffected by ordinary weak acids. They may also have surficial, chitinous, scalelike plates. The organism itself may be preserved as an impression or as a carbonaceous film, and under favorable conditions its trials and castings may be preserved.

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[1] The aid and suggestions of Drs. E. R. Eller and C. R. Stauffer are hereby gratefully acknowledged.

[2] **Caley, C. F.,** The Ordovician of Manitoulin Island, Ontario; Descriptions of new species — Vermes: *CGS, Mem* 202: 68–69, 1936. **Calvin, S.,** On a new genus and species of tubicolar Annelida [Iowa]: *Am G* 1: 24–28, 1888. **Clarke, J. M.,** Annelid teeth from Hamilton group and Naples shale of New York: *N Y St G*, An Rp 6: 30–33, 1887; Some Devonic worms: *N Y St Mus*, B 69: 1234–1238, 1903. **Croneis, C. G.,** and **Scott, H. W.,** Scolecodonts [Abst]: *GSA*, B 44: 207, 1933; Scolecodonts and conodonts from fissure fillings in the Niagaran of Illinois [Abst]: Idem; Scolecodonts from the Decorah formation of Missouri: Idem. **Eller, E. R.,** An articulated annelid jaw from the Devonian of New York: *Am Mid Nat* 14: 186, 1933; Annelid jaws from the Upper Devonian of New York: *Carnegie Mus*, An 22: 303–316, il, 1934; Scolecodonts, trails and burrows [Abst]: *GSA*, Pr 1934: 364–365, 1935; Annelid jaws from Hamilton of New York: *Carnegie Mus*, An 24: 51–56, il, 1934; A new scolecodont genus, *Ildraites*, from the Upper Devonian of New York: Idem 25: 73–76, il, 1936; Scolecodonts from Devonian of Michigan: Idem 27: 275–286, il, 1938; New Silurian scolecodonts from Albion of New York: Idem 28: 1–47, il, 1940; Removal of scolecodonts from the matrix: *Pa Ac Sc*, Pr 15: 119–120, 1941; Scolecodonts from the Erindale, Upper Ordovician, at Streetsville, Ontario: *Carnegie Mus*, An 29: 241–270, il, 1942. **Fenton, M. A.** and **C. L.,** *Scolithus* as a fossil Phoronid [Abst]: *GSA*, Pr 1933: 336, 1934. **Foerste, A. F.,** Notes on geological section at Todd's Fork, Ohio [Annelid jaws described on p 416–419]: *Am G* 2: 412–419, 1888 (see also *Ohio G S* 7: 517, 1893). **Gardner, J.,** The annelid genus *Tubulostium: USGS*, PP 193: 17–44, il, 1939. **Gries, P.,** Upper Ordovician scolecodonts from the Cincinnati area [Abst]: *GSA*, Pr 1933: 341, 1934. **Grinnell, G. B.,** Notice of a new genus of annelids from the Lower Silurian: *AJS* 14: 229–230, 1877. **Hinde, G. J.,** Annelid jaws from the Cambro-Silurian, Silurian, and Devonian formations of Canada: *G Soc London*, QJ 35: 370–389, il, 1879. **Howell, B. F.,** and **Mason, J. F.,** Reef-building Serpulid from Pleistocene of California [Abst]: *GSA*, Pr 1936: 359, 1937. **James, J. F.,** *Scolithus: GSA*, B 3: 32–44, il, 1892. **James, U. P.,** On conodonts and fossil annelid jaws: *Cin Soc N H*, J 7: 143–149, 1884–1885. **Johnson, H.,** Middle Silurian scolecodonts from Rochester, New York [Abst]: *GSA*, Pr 1937: 282, 1938. **Nicholson, H. A.,** On the genera *Cornulites* and *Tentaculites* and on a new genus *Conchicolites: AJS* 3: 202–206, 1872; On *Ortonia*, a new genus of tubicolar annelids with notes on the genus *Tentaculites: G Mag* 9: 446–449, 1872; Descriptions of two new species of fossil tubicolar annelids: *G Mag* 10: 45–47, 1873; Notes on a Carboniferous species of *Ortonia: G Mag* 10: 112–113, 1873. **Parks, W. A.,** and **Fritz, M.,** The stratigraphy and paleontology of Toronto and vicinity, III . . . Vermes: *Ont Dp Mines*, An Rp 31: 28–35, 1920. **Potter, F. C.,** Scolecodonts from the Upper Richmond of Illinois [Abst]: *GSA*, B 44: 208–209, 1933. **Ruedemann, R.,** Some Silurian (Ontarian) faunas of New York: *N Y St Mus*, B 265: 1–134, il, 1925. **Scott, H. W.,** The zoological relationships of the conodonts: *JP* 8: 448–455, 1934. **Searight, W. V.,** Fossil annelid jaws from the Iowa Devonian: *Ia Ac Sc*, Pr 30: 433–436, 1924. **Stauffer, C. R.,** Middle Ordovician Polychaeta from Minnesota: *GSA*, B 44: 1173–1218, il, 1933; Middle Devonian Polychaeta from the Lake Erie district: *JP* 13: 500–511, il, 1939. **Ulrich, E. O.,** Observations on fossil annelids and descriptions of some new forms: *Cin Soc N H*, J 1: 87–91, 1878. **Ulrich, E. O.,** and **Bassler, R. S.,** A classification of the toothlike fossils, conodonts, with descriptions of American Devonian and Mississippian species: *USNM*, Pr 68 (12): 1–63, il, 1926. **Wade, B.,** The fossil annelid *Hamulus* Morton, an operculate *Serpula: USNM*, Pr 59: 41–46, il, 1921. **Walcott, C. D.,** Middle Cambrian annelids: *SMC* 57: 109–144, il, 1911. **Weller, S.,** A new type of Silurian worm: *JG* 33: 540–544, il, 1925.

A few annelids build agglutinated calcareous or arenaceous tubes about themselves, and they remain free to move into or out of these. Such tubes are occasionally preserved.

Annelids are believed to have evolved in the Pre-Cambrian, though fossils of that age attributed to them are questionable.

CLASS CHAETOPODA
Subclass Polychaeta

Free-swimming or attached annelids; the former with jaws and scales, the latter secreting agglutinated, external tubes which are cemented to extraneous objects.

Order Phanerocephala (Errantia). This order includes a very large group of genera and species, many of which are still undescribed. Fossils consist of chitinous oesophageal jaws or scolecodonts and chitinous, scalelike plates like those found in living species. The first and second maxillae seem to be the most common as fossils, though the third and other maxillae, and even the mandibles, have also been found. The hollow of the individual jaws extends into the denticulations and these latter have no means of compensating for the wear incident to use and there is no provision for increasing the number of denticles. Muscle impressions or places of attachment are preserved, along with ridges and furrows, on the dental units. The surface scales or plates are rare, but the small, shiny black jaws are especially common at many horizons in Middle Paleozoic strata, and may be expected in rocks of all ages from the Cambrian to the most recently formed sediments. **Pre-Cambrian?–Recent.**

ARABELLITES Hinde 1879

(**A. hamatus*). Jaws of three kinds: (1) an extremely prominent anterior hook and row of smaller teeth on a wide base; (2) sickle-shaped jaws; and (3) quadrate jaws with straight upper edge of small teeth. **Ord.–Dev.** (widely distributed in southern Canada and eastern U. S. A.).

Ordovician species. **A. ovalis** (**91**—2), **A. cristatus** (**91**—8), **A. cuspidatus** (**91**—16), **A. gibbosus** (**91**—17), ***A. hamatus** (**91**—1), **A. lunatus** (**91**—5), and **A. scutellatus** (**91**—4), all Hinde's species, from the Maysville of Ont.; **A. giganteus** Stauffer (**91**—18) from the **M. Ord.** (Decorah) of Minn.

Silurian species. **A. elegans** Hinde (**91**—7) and **A. similis** Hinde (**91**—9) from the **L. Sil.** (Cataract) of Ont.; **A. oviformis** (**91**—14, 15), **A. plenidens** (**91**—20), and **A. rectidens** (**91**—12, 13), all Eller's species, from the **L. Sil.** of N. Y. (Albion).

Devonian species. **A. similis arcuatus** Hinde (**91**—10), and **A. politus** Hinde (**91**—3) from the Hamilton of Ont.; **A. comis** Eller (**91**—6) from Mich. (Potter Farm) and **A. marcellusensis** Eller (**91**—21) from N. Y. (Hamilton); **A. magnificus** Stauffer (**91**—11) from Ont. (Widder, Olentangy) and Ohio (Silica), and **A. priscus** Stauffer (**91**—19) from Ont. (Widder).

EUNICITES Ehlers 1868

(**E. avitus*). Minute, elongate, denticulate jaws with numerous teeth; subquadrate jaws with few teeth; simple, more or less curved, narrow hooks with denticles; impressions of worm itself have also been obtained from the Jurassic limestone of Bavaria. **Ord.–Eoc.** (reported from Ont. and many parts of U. S. A.).

Ordovician species. **E. contortus** (**91**—25), **E. gracilis** (**91**—31), **E. major** (**91**—28), and **E. simplex** (**91**—22), all Hinde's species, from Maysville of Ont.

Silurian species. **E. clintonensis** Hinde (**91**—24) from Cataract of Ont.; **E. coronatus** Hinde (**91**—26) from Clinton of Ont.; **E. falcatus** Foerste (**91**—32) from Medina of Ohio.

Devonian species. **E. grandis** Stauffer (**91**—27) from Olentangy of Ont.; **E. nanus** (**91**—23), **E. palmatus** (**91**—29), and **E. tumidus** (**91**—30), all Hinde's species, from Hamilton of Ont.

LUMBRICONEREITES Ehlers 1868

(**L. deperditus*). Jaws like *Eunicites*, but with a well defined basal extension. **Ord.–Dev.** (reported from Ont., and from numerous localities in U. S. A.).

Ordovician species. **L. cameratus** (**91**—39), **L. superbus** (**91**—45), and **L. webbi** (**91**—36), all Stauffer's species, from Platteville and Decorah of Minn.; **L. dactylodus** Hinde (**91**—38) from **U. Ord.** of Ont.

Silurian species. **L. armatus** (**91**—37), **L. basalis** (**91**—35), and **L. triangularis** (**91**—33), all Hinde's species, from Cataract of Ont.; **L. austini** Foerste (**91**—40) from Medina of Ohio; **L. hibbardi** Eller (**91**—43, 44) from Albion of N. Y.

Devonian species. **L. cooperi** Eller (**91**—41, 42) from Mich. (Potter Farm), and **L. expansus** Stauffer (**91**—34) from Ohio (Silica).

NEREIDAVUS Grinnell 1877

(**N. varians*). Jaws elongate with blunt denticles, a distinct hook, and a truncated posterior end. **Ord.–Dev.** (Ont.; eastern U. S. A.).

Ordovician species. ***N. varians** Grinnell (**91**—46) from **U. Ord.** of Ohio.

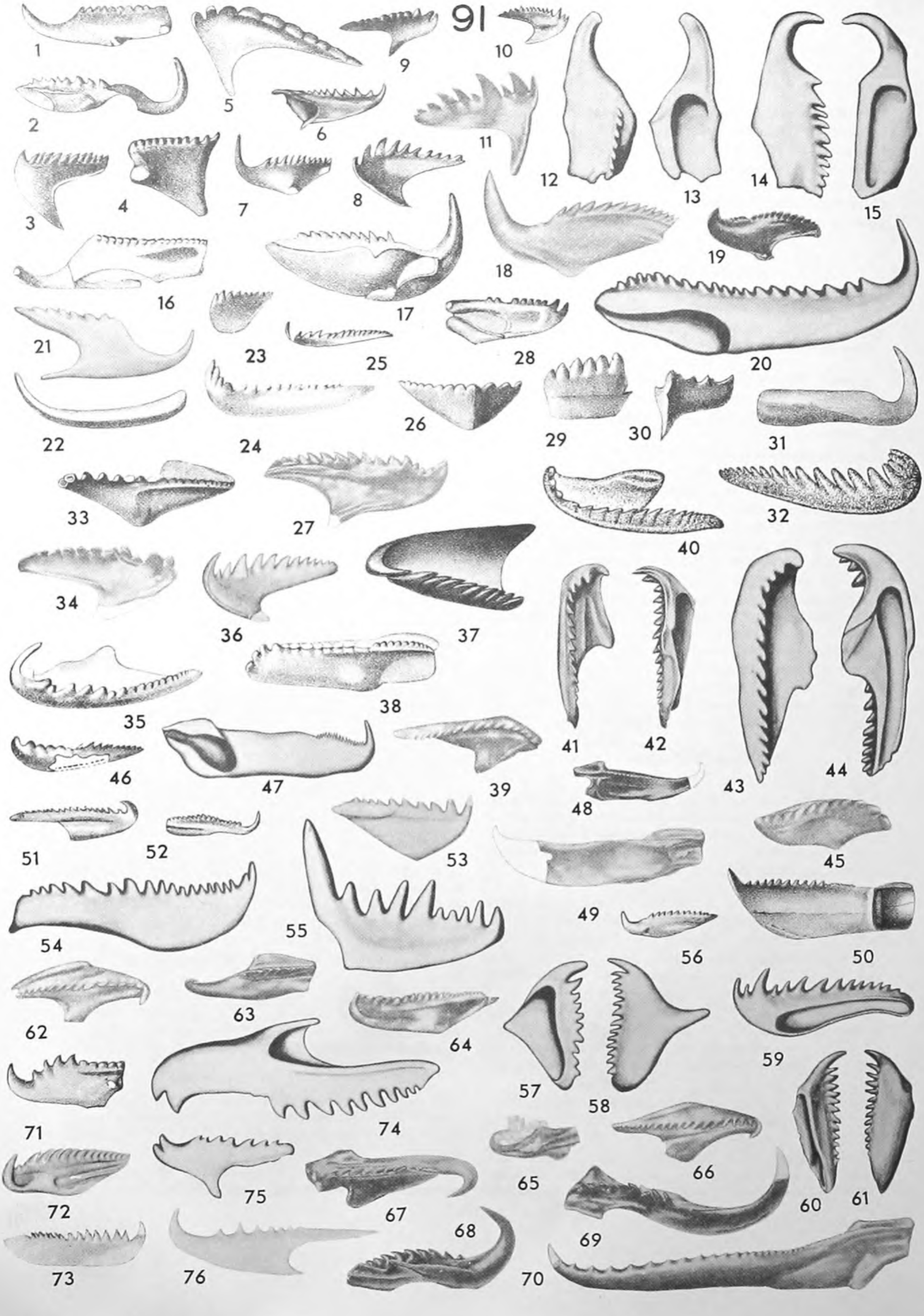
Silurian species. **N. invisibilis** Eller (**91**—47) from N. Y. (Albion).

Devonian species. **N. ontarioensis** Stauffer (**91**—48) from Ont. (Olentangy, etc.); **N. planus** Stauffer (**91**—49) from Ont. (Olentangy) and Ohio (Silica); **N. solitarius** Hinde (**91**—50) from Ont. (Hamilton).

OENONITES Hinde 1879

(**O. curvidens*). Jaws with more or less curved anterior hook, followed by a series of smaller teeth like those of the modern *Oenone*. **Ord.–Dev.** (same distribution as preceding genera).

Ordovician species. **O. cuneatus** (**91**—56), ***O. curvidens** (**91**—51), **O. rostratus** (**91**—71), and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O. serratus (**91**—52), all Hinde's species, from Ont. (Maysville); **O. excelsus** (**91**—72) and **O. tacitus** (**91**—53), Stauffer's species, from Minn. (Decorah).

Silurian species. **O. amplus** Hinde (**91**—73) from Ont. (Cataract); **O. acinaceas** (**91**—55), **O. coalescens** (**91**—54), **O. exactus** (**91**—59), and **O. fornicatus** (**91**—57, 58), all Eller's species, from N. Y. (Albion).

Devonian species. **O. orthodontus** Eller (**91**—60, 61) from Mich. (Potter Farm) .

ILDRAITES Eller 1936

(**Arabellites bipennis*). Anterior extremity of jaws of maxillae I has an extremely prominent pointed hook and a row of several usually acute denticles along the nearly straight inner lateral margin; anterior part very similar to *Arabellites*, but posterior is sickle-shaped by a deep, crescent-shaped bight while posterior end of *Arabellites* is obliquely truncate. **Sil., Dev.** (eastern U. S. A.)

I. duplex Eller (**91**—74, 75) **L. Sil.:** N. Y. (Albion).

***I. bipennis** (Eller) (**91**—76) **U. Dev.:** N. Y. (Alfred).

PROTARABELLITES Stauffer 1933

(**P. humilis*). Jaws and plates somewhat like those of *Arabellites*, but base is much expanded laterally or has a flange extending along major portion of both inner and outer sides; denticulated ridge has 18 to 22 teeth and terminates anteriorly in a prominent hook. **Ord.–Dev.** (Ont.; eastern U. S. A.).

Ordovician species. **P. concavus** (**91**—66) and **P. glenwoodensis** (**91**—64), both Stauffer's species, from Minn. (Glenwood); ***P. humilis** (**91**—65) and **P. productus** (**91**—62), both Stauffer's species, from Minn. (Decorah).

Devonian species. **P. canadensis** (**91**—67, 68), **P. excelsus** (**91**—69), **P. giganteus** (**91**—70), **P. hamiltonensis** (**91**—63), all Stauffer's species, from **M. Dev.** of Ont. (last species also from Ohio).

Order Cryptocephala (Sedentaria, Tubicola). Attached polychaetes lacking jaws, with little developed parapodia in posterior portion and anterior parapodia modified; these secrete an external tubular shell, tapering posteriorly and straight, sinuous or coiled; tubes occur either as solitary individuals or in clusters, with some of latter reef-builders. **Ord.–Recent.**

SERPULA Linnaeus 1746

(**S. vermicularis*). Calcareous tubes, free or adherent, firm, irregularly contorted, in some forms spirally coiled and frequently clustered together in large numbers; from Jurassic onward the usual condition is attached to other fossils. **Sil.?–Recent** (uncommon before **Cret.**; common in modern seas).

S. pervermiformis Wade (**92**—12). Tubes very small, circular in cross-section, highly intertangled and coiled; external surface roughened with transverse growth lines; internal surface smooth; shell material of two layers; tubes commonly attached to *Exogyra costata* Say and other shells. **U. Cret.** (Ripley): Tenn.

S. dianthus Verrill. Singly adhering to shells, or growing in complex clusters, often making large masses; tubes contorted, averaging 3 mm in diameter. **Pleist.:** Massachusetts (Sankaty). **Recent** along Atlantic Coast.

SPIRORBIS Lamarck 1801

(**Serpula spirorbis* Linnaeus). Minute, snail-like calcareous tubes cemented by flat underside; spiral coiling dextral or sinistral; external ornamentation of concentric striae or annulations, and sometimes of tubercles or spines; living species (marine) commonly adhering to seaweeds. **Ord.–Recent** (common and widespread throughout the geologic column in N. America; commonly attached to various fossil shells).

S. laxus Hall (**92**—1–4). Coiled, often irregularly; whorls round with sharp annulations. **Sil.:** Mich. (Raisin River), Tenn. (U. Manlius). **Dev.** (Helderbergian): N. Y.

S. angulatus Hall. Tube with two or more volutions, the outer robust; sides subangular; upper angular surface sometimes nodose; aperture round or oval, usually nearly at right angles to plane of spiral. **M. Dev.** (Hamilton): Ont.; N. Y., Ohio, Ill.

PLATE 91

[Figures are after Hinde [Geol Soc London, QJ 35] unless otherwise indicated; CM, An = Carnegie Museum, Annals.]

1–21. Arabellites spp. 1. A. hamatus (x20). 2. A. ovalis (x10). 3. A. politus (x15). 4. A. scutellatus (x16). 5. A. lunatus (x10). 6. A. comis (x18) [CM, An 27]. 7. A. elegans (x14). 8. A. cristatus (x13). 9. A. similis (x17). 10. A. similis arcuatus (x18). 11. A. magnificus (x45) [JP 13]. 12, 13. A. rectidens (x35) [CM, An 28]. 14, 15. A. oviformis (x35) [CM, An 28]. 16. A. cuspidatus (x7)? 17. A. gibbosus (x10). 18. A. giganteus (x30) [GSA, B 44]. 19. A. priscus (x45) [JP 13]. 20. A. plenidens (x35) [CM, An 28]. 21. A. marcellensis (x10) [CM, An 24]. 22–32. Eunicites spp. 22. E. simplex (x13). 23. E. nanus (x15). 24. E. clintonensis (x13). 25. E. contortus (x8). 26. E. coronatus (x14). 27. E. grandis (x20) [JP 13]. 28. E. major (x3). 29. E. palmatus (x15). 30. E. tumidus (x13). 31. E. gracilis (x14). 32. E. falcatus (x20) [Am G 2). 33–45. Lumbriconereites spp. 33. L. triangularis (x10). 34. L. expansus (x30) [JP 13]. 35. L. basalis (x10). 36. L. webbi (x35) [GSA, B 44]. 37. L. armatus (x10). 38. L. dactylodus (x6). 39. L. cameratus (x30) [GSA, B 44]. 40. L. austini (x15) [Am G 2]. 41, 42. L. cooperi (x18) [CM, An 27]. 43, 44. L. hibbardi (x3) [CM, An 28]. 45. L. superbus (x30) [GSA, B 44]. 46–50. Nereidavus spp. 46. N. varians (x3.5). 47. N. invisibilis (x35) [CM, An 28]. 48. N. ontarioensis (x45) [JP 13]. 49. N: planus (x20) [JP 13]. 50. N. solitarius (x15). 51–61. Oenonites spp. 51. O. curvidens (x15). 52. O. serratus (x12). 53. O. tacitus (x60) [GSA, B 44]. 54. O. coalescens (x35) [CM, An 28]. 55. O. acinaces (x35) [CM, An 28]. 56. O. cuneatus (x16). 57, 58. O. fornicatus (x35) [CM, An 28]. 59. O. exactus (x35) [CM, An 28]. 60, 61. O. orthodontus (x18) [CM, An 27]. 62–70. Protarbellites spp. [GSA, B 44]. 62. P. productus (x30). 63. P. hamiltonensis (x30). 64. P. glenwoodensis (x30). 65. P. humilis (x30). 66. P. concavus (x30). 67, 68. P. canadensis (x45). 69. P. excelsus (x30). 70. P. giganteus (x15). 71–73. Oenonites spp. 71. O. rostratus (x15). 72. O. excelsus (x35) [GSA, B 44]. 73. O. amplus (x14). 74–76. Ildraites spp. 74, 75. I. duplex (x35) [CM, An 28]. 76. I. bipennis (x13) [CM, An 22].

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S. arkonensis Nicholson (**92**—5, 6). Minute; sinistral or dextral, of two whorls with latter elevated and large; aperture circular; surface with very fine, closely set, threadlike transverse striae. **M. Dev.** (Hamilton): Ont.; N. Y.

S. omphalodes Goldfuss (**92**—7). Larger than preceding and with smooth surface. **M. Dev.** (Hamilton): Ont.; N. Y., Wis.; Europe.

S. annulatus Hall (**92**—8). Irregularly planospiral, with sharp annulations separated by finer ones. **M. Miss.** (Salem): Ind., Ill.

S. nodulosus Hall. Volutions strongly deflected, subangular, with oblique ridges or striae which become strongly nodose on umbilical side. Range and distribution as in preceding.

S. anthracosia Whitfield (**92**—9, 10). Rather high-spired; volutions angular near suture and irregularly noded; surface with only coarse growth lines. **Penn.:** Ohio, Okla.

S. calvertensis Martin (**92**—11). Small tubes about 1.3 mm in diameter, attached to molluscan shells; surface with indistinct, somewhat irregular annulations; coils somewhat sharply ridged on top. **Mioc.:** Md. (Calvert).

CORNULITES Schlotheim 1820

(= CONCHICOLITES Nicholson 1872, ORTONIA Nicholson 1872)

(**C. serpularius*). Calcareous trumpet-shaped tubes, gently tapering, flexuous, with small end usually bent; closed at lower end and either wholly or partly adhering to extraneous objects (shells, etc.); length as much as 8 to 10 cm; walls thick, cellular, composed of imbricating rings; surface ornamented with annulations and longitudinal striae; interior presenting a succession of ringlike constrictions, giving the surface of internal fillings a steplike appearance; shells sometimes in clusters. **Ord.–Penn.** (common and widespread in U. S. A.).

C. corrugatus (Nicholson) (**92**—15, 16). Tubes irregularly annulated, often united; rings about 20; diameter at aperture 1 to 2 mm. **U. Ord.:** Cincinnati region (Maysville).

C. flexuosus (Hall) (**92**—17). Tubes single or aggregate; surface marked by strong annulations, somewhat irregular; interior distinctly septate, septa with concave sides up. **M.** and **U. Ord.:** N. Y. (Trenton, Pulaski), Pa., Ohio (Maysville), Ky.

C. minor (Nicholson) (**92**—14). Annulations sometimes faintly marked on side opposite attached surface, about 15 in 2 mm; curvature simple or S-shaped; length 2 to 6 mm; diameter at aperture about 1 mm. **Ord.:** Ohio (Maysville).

C. arcuatus Conrad (**92**—19, 20). Regularly tapering, sometimes curved. **Sil.:** N. Y. (Lockport, Cobleskill, Guelph); **U. Monroan** of Ont. and Mich

C. bellistriatus Hall (**92**—18). Annulations scarcely marked at base, less strongly and irregularly marked in upper portion and more regular than in *C. proprius* (of which it may be only a variety); fine longitudinal striae throughout. **M. Sil.** (Niagaran): Ont.; N. Y. (Rochester).

C. proprius Hall. Rapidly enlarging tubes adhering when young; strongly and regularly annulated; adult up to 8 cm long, with irregular lamellose growth lines and fine longitudinal striae; structure vesiculose. **M. Sil.** (Niagaran): N. S.; Ind.; Tenn.

C. cingulatus Hall (**92**—13). **Dev.:** N. Y. (New Scotland, Oriskany), Md., N. J.

HAMULUS Morton 1834

(**H. onyx*). Symmetrical conical tube, small, elongate, gently curved and longitudinally ribbed with three to seven axial ribs; consisting of an inner layer of lamellar calcareous material and an outer chitinocalcareous one bearing the external sculpture; nuclear shell portions circular and often triangular in cross-section; inner surface of tube smooth; aperture circular, closed by a tack-shaped operculum; tube attached in youth, usually broken away and solitary in adult. **Cret.** (widespread and common in Atlantic and Gulf Coast regions)**–Recent.**

***H. onyx** Morton (**92**—21–24). **U. Cret.:** Md. (Monmouth), S. C. (Peedee), Tenn. (Ripley), Ala. and Miss. (Ripley, Selma), Ala. (Eutaw), Ark., Tex. (Navarro); Mex. (Cardenas).

H. squamosus Gabb (**92**—25). Distinguished from preceding by its broad, winglike appendages on the first and fourth axial costae. **U. Cret.** (Ripley): *Exogyra ponderosa* and *E. costata* zones of Gulf Coast region.

TUBULOSTIUM Stoliczka 1868

(**Serpula spirulaea* Lamarck [questionable]). Small shelly tubes coiled in a single or nearly single plane,

PLATE 92

[Figures are x1 unless otherwise indicated.]

1–11. Spirorbis spp. 1–4. S. laxus [Pal N Y 3]. Upper and lower sides of a closely coiled shell, and two loosely coiled shells, all greatly enlarged. **5, 6. S. arkonensis** [Nicholson: Manual Pal 1]. A sinistral and a dextral shell, much enlarged, and a shell (x1). **7. S. omphalodes** [Nicholson: Manual Pal 1]. A shell (x1) and same much enlarged. **8. S. annulatus,** much enlarged [AMNH, B 1]. **9, 10. S. anthracosia,** much enlarged [N Y Ac Sc, An 5]. **11. S. calvertensis,** attached to a shell, and enlarged [Md G S, Mioc]. **12. Serpula pervermiformis** (x3) [USGS, PP 137]. **13–20. Cornulites spp. 13. C. cingulatus,** enlarged [Md G S, L Dev]. **14. C. minor,** enlarged [G Mag 10]. **15, 16. C. corrugatus** [Pal N Y 5]. A group of tubes attached to a shell, and a single one enlarged. **17. C. flexosus** [Md G S, Camb, Ord]. **18. C. bellistriatus** [Pal N Y 5]. **19, 20. C. arcuatus** (x2) [N Y St Mus, M 5]. **21–25. Hamulus spp.** [USGS, PP 137]. **21–24. H. onyx.** Top and side views (x10) of an operculum, a nearly complete specimen (x4), and a top view of same specimen with operculum in place. **25. H. squamosus** (x4). **26–28. Tubulostium mcglameryae** (x5) [USGS, PP 193]. Top and side views, and a transverse section. **29, 30. Arenicolites woodi** [Geol Wis 4]. Top view of burrows showing round and crescentic openings, and longitudinal section. **31, 32. Scalarituba welleri** [U Mo Stud 13]. A portion of trail enlarged (x2), two specimens (x0.3). **33–35. Scolithus spp. 33. S. clintonensis** [GSA, B 3]. **34. S. linearis** [USGS, An Rp 10]. Tubes filled with sand of a darker color than the matrix. **35. S verticalis** [GSA, B 3].

irregular, and attached during initial growth stages; tubes may be flattened on one side; apertural extremity free from body wall and may be tangent to it for some distance. **U. Cret., Early Tert.** (worldwide distribution).

T. mcglameryae Gardner (**92**—26–28). **Paleoc.:** Ala. (Midway).

CLASS SIPUNCULOIDEA (GEPHYREA)

Fossils of this class are burrows and burrow fillings which appear to have been made by organisms closely related to modern burrowing marine worms. Some of the burrows are nearly straight holes, others are semielliptical, and still others are variously curved and contorted. Commonly these burrows are filled with castings of detrital material differing slightly from the inclosing sediment and are thus quite conspicuous, especially when the rock is weathered. Occasionally the granular filling weathers out as a straight or curved rod. Burrows and fillings are abundant in the Upper Cambrian and common in Ordovician and later rocks, particularly in fine-grained, highly argillaceous limestones. Their presence in abundance is almost always a sure sign of absence or scarcity of other fossils.

ARENICOLITES Salter 1857

(**Arenicola didyma*). Circular holes, generally in sandstones, occurring in pairs and resembling the U-shaped burrows of the modern *Arenicola*. **Camb.–Dev.** (U. S. A.).

A. woodi Whitfield (**92**—29, 30). Seldom as much as 2 mm in diameter, generally somewhat less; deflected at various angles near surface of layer and often oblique for some distance, then horizontal along stratification plane; natural openings surrounded by hillocks; older borings compressed by new ones so as to appear crescentic in section. **U. Camb.:** Wis.

SCALARITUBA Weller 1899

(**S. missouriensis*). Irregularly curving and twisting worm burrows marked by transverse ridges at a distance of 1 to 2 mm. **L. Miss.** (Mo.).

***S. missouriensis** Weller. Tubes 2 to 4 mm in diameter, subcylindrical, never straight for more than a few centimeters. **Kinderhookian:** Mo. (Northview).

S. welleri Branson (**92**—31, 32). Same as preceding.

SCOLITHUS Haldeman 1840[1]
(= SKOLITHOS Haldeman 1840)

(**Fucoides? linearis*). Tube free, cylindrical or subcylindrical, vermiform; never branched and usually vertical or near vertical in position. **Camb.–Dev.** (common and widespread throughout U. S. A., but of little or no stratigraphic value).

***S. linearis** (Haldeman) (**92**—34). Surface nearly smooth, sometimes apparently striated; form rigidly straight; diameter 3 to 12 mm; length 0.1 to 0.5 m. **Camb.:** Newf.; Vt., Mass. (in boulders), N. Y., Pa., Va. (in boulders), Tenn., Wis. (Fenton and Fenton (1934) think this fossil may be a phoronid boring.)

Numerous other species of *Scolithus* have been erected, e.g. *S. clintonensis* James[2] (**92**—33), from the **Clinton** and *S. verticalis* Hall (**92**—35), from the **Portage,** but there is considerable doubt as to whether some, or any, of these are valid species.

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[1] In 1840, Haldeman [Suppl. "A Monograph of the Limniades of North America," p. 1] wrote, under the heading *Fucoides? linearis*, "I discovered this fossil in 1835, and described it about three years ago [This earlier reference was not found; it is not listed in the Nomenclators of Sherborn, Neave, or Schulze, and possibly Haldeman was not referring to an actual published description.] as *Skolithos linearis*, proposing a subgenus for it . . ." Howell (1940) recently called attention to this spelling and suggested that it be recognized. It is the feeling of the authors, however, that less confusion will result from retaining the revised spelling, even though a strict application of the rules requires use of the original spelling in this instance.

[2] Howell (1940, 1972) states that burrows probably referable to this species have been found in the **Clinton** of Pa. and, because they have funnel-shaped apertures, may be referable to *Monocraterion* Torell, which occurs in **L. Camb.–L. Ord.** strata.

CHAPTER VII

CONODONTS[1]

PREPARED BY EDWIN B. BRANSON AND MAURICE G. MEHL

Introduction. Conodonts were first made known in 1856, but they remained little more than scientific curiosities for nearly three-quarters of a century. The work on conodonts by Ulrich and Bassler in 1926 served as a stimulus to investigations, and subsequent years have witnessed a large increase in the number of students of this group and consequently a remarkable increase in the number of described genera and species and knowledge of their geographic and stratigraphic range. Illustrations of their usefulness in close stratigraphic determination are so many that the conodonts have taken a definite place among the more useful of the microfossil groups.

Nature of Conodonts. Conodonts range in size from a fraction of a millimeter to more than 2 mm in length. They are composed of calcium phosphate with characteristics much like those of apatite. Conodonts have two distinct types of structure, *fibrous* and *sheathed* or *laminar*. Tne former is comparable to a bundle of fibres, and some forms with this structure have been found crushed and frayed rather than broken. The other group seems to be made up of layers, the conical forms being comparable to a series of slender nested cones. Such forms when viewed with transmitted light commonly show successive tips of cones that outline a "growth axis."

Conodonts have a specific gravity somewhat greater than that of calcite, dolomite, and quartz and are, therefore, easily separated from most associated sediments by heavy liquids such as tetrabromoethane. Although quickly destroyed by weak hydrochloric acid, they are not affected by acetic acid and may be segregated readily from limestone by its use. Conodonts are translucent or nearly transparent and range in color from pale amber to light brown. With few exceptions they are shiny, but some show a satinlike surface that is probably the result of chemical weathering — a common condition in some limestones. They are readily distinguished from worm jaws (*scolecodonts*) by the distinctive shapes and the jet black color of the latter. The most important distinguishing feature, however, is the difference in composition.

Sedimentary Association. Unctuous shales or clays, particularly at the bottom or top of a member, are likely to yield more conodonts than other kinds of rock; hard, fissile black shales rank second in productivity. Thin sandstones interbedded with

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[1] **Branson, C. C.,** Conodonts from tne Permian Phosphoria of Wyoming: *Science* ns 75: 337–338, 1932. **Branson, E. B., and Mehl, M. G.,** Conodont studies [9 papers]: *U Mo Stud* 8: 1–300, pl 1–28, 1933, 1934 [p 1–171, pl 1–12, 1933; p 172–300, pl 13–28, 1934]; The conodont genus *Icriodus* and its stratigraphic distribution: *JP* 12: 155–166, 1938; Conodonts from the Lower Mississippian of Missouri: *U Mo Stud* 13: 128–137, 1938; A record of typical American conodont genera in various parts of Europe; The recognition and interpretation of mixed conodont faunas; Caney conodonts of Upper Mississippian age; Conodonts from the Keokuk formation: *DUB, JSL* 35: 167–219, il, 1940; New and little known Carboniferous conodont genera: *JP* 15: 97–106, il, 1941. **Branson, E. R.,** Conodonts from the Hannibal formation of Missouri: *U Mo Stud* 8 (4): 301–334, il, 1934. **Bryant, W. L.,** The Genesee conodonts: *Buffalo Soc N Sc*, B 13: 1–58, pl 1–16, 1921. **Cooper, C. L.,** Conodonts from the Arkansas novaculite, Woodford formation, Ohio shales and Sunbury shale: *JP* 5: 143–151, 1931; New conodonts from the Woodford of Oklahoma: *JP* 5: 230–245, il, 1931. **Cullison, J. S.,** Dutchtown fauna of southeastern Missouri: *JP* 12: 219–228, 1938. **Eichenberg, W.,** Conodonten aus dem Culm des Harzes: *Pal Zeitschr*, Bd 12: 177–182, 1930. **Ellison, S.,** Revision of the Pennsylvanian conodonts: *JP* 15: 107–143, 1941. **Furnish, W. M.,** Conodonts of the Prairie du Chien (Lower Ordovician) beds of the Upper Mississippi valley: *JP* 12: 318–340, il, 1938. **Gunnell, F. H.,** Conodonts from the Fort Scott limestone of Missouri: *JP* 5: 244–255, il, 1931; Conodonts and fish remains from the Cherokee, Kansas City, and Waubansee groups of Missouri and Kansas: *JP* 7: 261–297, il, 1933. **Harris, R. W.,** Descriptions of ostracodes and conodonts (Simpson): *Okla G S*, B 55: 87–95, 1931. **Harris, R. W., and Hollingsworth, R. V.,** New Pennsylvanian conodonts from Oklahoma: *AJS* (5) 25: 193–204, il, 1933. **Hass, W. H.,** Morphology of conodonts: *JP* 15: 71–81, il, 1941. **Hibbard, R. R.,** Conodonts from the Portage group of western New York: *AJS* (5) 13: 189–208, il, 1927. **Hinde, G. H.,** On Cambro-Silurian and Devonian conodonts: *GSL*, QJ 35: 351–369, 1879. **Holmes, G. B.,** A bibliography of conodonts with descriptions of early Mississippian species: *USNM*, Pr 72: 1–38, 1928. **Huddle, J. W.,** Conodonts from the New Albany shale: *B Am Pal* 21: 1–137, il, 1934. **Matern, H.,** Neue Conodonten aus Devon und Unterkarbon Senckenbergiana: *Senck Nat Ges*, Bd 15: 12–22, 1933. **Pander, O. H.,** Monographie der Fossilen Fische des Silurischen Systems der Russich-Baltischen Gouvernements, p 1–91, il, 1856. **Schmidt, H.,** Conodontenfunde in ursprunglichen Zusammenhang: *Pal Zeitschr*, Bd 16: 76–85, 1934. **Scott, H. W.,** Zoological relationships of conodonts: *JP* 8: 448–455, il, 1934. **Stauffer, C. R.,** Conodonts from the Decorah shale: *JP* 4: 121–128, 1930; Decorah shale conodonts from Kansas: *JP* 6: 257–264, 1932; Conodonts from the Glenwood beds: *GSA*, B 46: 125–268, il, 1935; Conodonts of the Olentangy shale: *JP* 12: 411–443, il, 1938. **Stauffer, C. R., and Plummer, H. J.,** Texas Pennsylvanian conodonts and their stratigraphic relations: *U Tex B* 3201: 13–50, il, 1932. **Ulrich, E. O., and Bassler, R. S.,** A classification of the toothlike fossil conodonts with descriptions of American Devonian and Mississippian species: *USNM*, Pr 68: 1–63, pl 1–11, 1926. **Zebera, K.,** Les Conodonts et les Scolecodontes du Barrandien: *Cesk Akad B Int*, An 36: 86–96, 1935.

shales, thin earthy limestones similarly interbedded, and relatively pure limestones all yield some conodonts. There is evidence that some conodonts in limestones represent sedimentary introductions rather than records of environment. It is reasonably certain that the normal conodont environment was near shore in moderately shallow marine waters containing some clay, possibly somewhat modified by fresh waters around debouchures of streams. The great abundance of conodonts in unctuous clays at the top of some formations probably resulted from concentration in the residuum on weathered surfaces.

Conodonts as Horizon Markers. Conodonts are exceptionally good horizon markers within their stratigraphic range. From their first appearance as simple conelike forms to the development of highly complicated groups, their entire history is written in a single era, the Paleozoic.

In the compilation of range charts of genera one discovers misleading data that result from lack of information. Because little is known about Silurian and Devonian forms, the charts indicate a much greater lack of continuity of genera across the Ordovician-Silurian and the Silurian-Devonian intervals than probably exists.

Many of the genera and probably a large number of species are common to North America and Europe. Rapid evolution of genera and species coupled with rapid lateral spread, resistance to chemical weathering, and ease of segregation of large numbers from small amounts of unctuous sediments all recommend conodonts for use in correlation. Their small size and distinctive shapes make them recognizable in well cuttings even though they may be only broken fragments.

Zoological Affinities. Conodonts have been assigned by various students to Crustacea, Cephalopoda, Gastropoda, Annelida, and Vertebrata. Most investigators assume that they represent jaw armor of an extinct order of primitive fishes. This opinion is based on the chemical composition, nature of growth additions, and actual attachment of many specimens to jaw substance. Some writers believe that three or more distinctive groups, each designated a genus by others, represent a single individual. Associated groups are explained in this way or are considered accidental associations in coprolites of predators.

Problems. The problems peculiar to conodonts center around the lack of satisfactory information about their zoological identity and function (association of parts), and their durability under chemical weathering. Because little is known about the relationships of the teeth to each other and to the rest of the organism, some writers imply that lists of generic and specific occurrences are of doubtful value. Granting, for purposes of illustration, that more than one so-called genus represents one individual, the stratigraphic range of any distinctive part of this composite, the so-called species, loses none of its value. The only offense of such usage is against biological veracity.

Because of their small size, conodonts are resistant to wear during transportation, and chemical weathering affects them only slightly. Consequently there are limitless possibilities that specimens, weathered from rocks of one age, may be carried into a later sea or left as residuum to be reworked by an invading sea of later date, thus giving rise to mixed faunas. Many illustrations of mixed faunas are known, including such anomalous associations as Ordovician, Devonian, and Mississippian forms in a single unit only a few inches thick. The problem of such faunas is not so much that of interpretation as one of recognition. Obviously the youngest assemblage present fixes the age of the inclosing matrix. The interpretation presupposes a fair knowledge of the succession of faunas; lack of such knowledge might well result in recording genera or species in rocks younger than the actual range. Conodonts may be introduced as leaks into older rocks through filling of caverns and cracks by sediment deposited from ground water or from invading seas.

Preparation Techniques. There is no efficient way to remove conodonts from hard fissile shales. Specimens imbedded in such a shale surface have the disadvantage of exposing only one side. Representatives of one species have been assigned to different genera because they were studied from different sides. Many shales break down readily with boiling, as do some limestones. Limestone digested in a 10 to 15% solution of glacial acetic acid yields a sludge that may contain conodonts and may be boiled and cleaned in the same manner as the less stubborn shales. Boiling followed by careful flushing leaves a clean residue that may be dried and later screened. No conodonts remain on 20-mesh and few pass 80-mesh sieves. Residues from washing and screening, not largely composed of phosphate nodules, iron, or other heavy minerals, may be floated by a heavy liquid while the conodonts settle out.

A quick-drying, thin-bodied cement insoluble in water seems most efficient for mounting conodonts for photography and study. Heavy-bodied cements may crack delicate specimens through drying shrinkage, and water soluble cements do not permit the use of water for removing dust particles from specimens before photography. Most conodonts are so glossy as to give troublesome light reflection which interferes with photography. Polarizing screens have been used with slight success to correct this, but a very thin film of sal ammoniac, deposited by sublimation (heated in a glass tube and blown with a bulb — not the moist breath) on the specimen and background, facilitates study of delicate external features and gives uniform surfaces for photography.

Descriptive Terminology. Conodonts are paired, *right* and *left* or *upper* and *lower*, with reversed

curves and other features. In describing a genus it is conventional to assume an *inner* and *outer side* with reference to a curvature or some other feature and the assumed *anterior* end is designated. *Oral* and *aboral* are used to designate the functioning or mouth cavity side and the attachment side. Simple conical forms are commonly set on the expanded end for description. Most cones are curved; the curved side is *anterior*, the concave *posterior*. *Proximal* and *distal* are conventional designations among cones for attachment and free ends. Certain genera may require special terminology.

Classification. Genera known to be well founded are described and illustrated below. They are grouped in families and suborders in an attempt to indicate genetic relationships. There are still too many gaps in conodont knowledge, however, to justify the assumption that the groupings are correct. Data for specific determination are omitted in the text because specific values are not agreed upon and specific determinations require detailed study of specimens.

Order Conodontophoridia. Order based on minute teeth of various shapes ranging from simple cones to complex plates composed of calcium phosphate and attached to fragments of similar composition assumed to have been jaws.

Suborder Neurodontiformes [Branson and Mehl: 1942]. Conodontophoridia with teeth composed of bundles of fibers.

COLEODONTIDAE [New]. Teeth fibrous, clasping the jaw rather than resting platelike on the ramus or clasping its anterior end.

COLEODUS Branson and Mehl 1933

(**C. simplex*). Dental unit bladelike with thin, crenulate oral edge; aboral edge deeply grooved longitudinally. **M. Ord.** (Mo., Okla., Colo.).

***C. simplex** B and M (**93**—22). **M. Ord.:** Mo. (Dutchtown), Colo. (Harding).

ERISMODUS Branson and Mehl 1933

(**E. typus*). Arched, barlike dental units with large apical denticle that extends aborally as a buttress on inner and outer sides; limbs of arch discrete, more or less rounded denticles; aboral side longitudinally excavated. **M. Ord.** (Que.; Minn., Mo., Colo.).

***E. typus** B and M. **M. Ord.:** Colo. (Harding).

E. sp. (**93**—14). **M. Ord.:** Mo. (Dutchtown).

NEOCOLEODUS Branson and Mehl 1933

(**N. spicatus*). Bladelike or barlike dental units with oral edge deeply notched to produce discrete nodes or spikes; aboral edge longitudinally grooved. **M. Ord.** (Mo., Okla., Colo.).

***N. spicatus** B and M (**93**—20). **M. Ord.:** Colo. (Harding).

CHIROGNATHIDAE [New]. Fibrous conodonts that clasp or tip the end of the jaw ramus.

CHIROGNATHUS Branson and Mehl 1933

(**C. duodactyla*). Hand-shaped dental units; denticles pointed, subcircular in section; base slightly excavated but lacking pulp cavity. **Ord.** (Minn., Mo., Okla., Colo.).

***C. duodactyla** B and M. **M. Ord.:** Minn. (Glenwood), Colo. (Harding).

C. alternata B and M (**93**—12). **M. Ord.:** Colo. (Harding).

LEPTOCHIROGNATHUS

Branson and Mehl 1942

(**L. quadrata*). Hand-shaped dental units with pointed, compressed, sharp-edged denticles; base slightly excavated but lacking pulp cavity; sharp edged denticles differentiate it from *Chirognathus*. **M. Ord.** (Minn., Mo., Ark., Okla., Tex.).

***L. quadrata** (**93**—11), **L. coalescens** (**93**—1), and **L. semifloralis** (**93**—13), all described by Branson and Mehl and all recorded from the **Mid-Ord.** of Okla. (McLish).

MULTIOISTODUS Cullison 1938

(**M. subdentatus* Cullison (**93**—10, 19) from **M. Ord.** of Mo. (Dutchtown)). Recurved cones with base expanded posteriorly, a smaller median cone projecting backward from base, with or without a posterolateral cone on one or both sides. **M. Ord.**

STEREOCONUS Branson and Mehl 1933

(**S. gracilis*). Discrete recurved cones without basal excavation. **M. Ord.** (Mo., Colo., Wyo.).

***S. gracilis** B and M (**93**—16, 21). **M. Ord.:** Colo. (Harding).

TRUCHEROGNATHIDAE [New]. Platelike fibrous teeth that rest on the jaw ramus rather than clasping it or tip of jaw.

AMBOLODUS Branson and Mehl 1933

(**A. triangularis* B and M (**93**—7, 8) from the **U. Ord.** (Maquoketa-Thebes) of Mo.). Platformlike dental units; triangular or crescentic in outline; two sides of oral edge produced into a denticulate parapet with the largest denticle at the union of the two rows; aboral surface smooth, concave. **Ord.**

AMORPHOGNATHUS Branson and Mehl 1933

(**A. ordovicica*). Flat or slightly arched dental units with more or less lanceolate branches that produce an irregular outline; branches with median row of nodes or denticles on oral side; aboral side smooth to keeled. **Ord.** (Minn., Mo.).

***A. ordovicica** B and M. **U. Ord.:** Mo. (Maquoketa-Thebes).

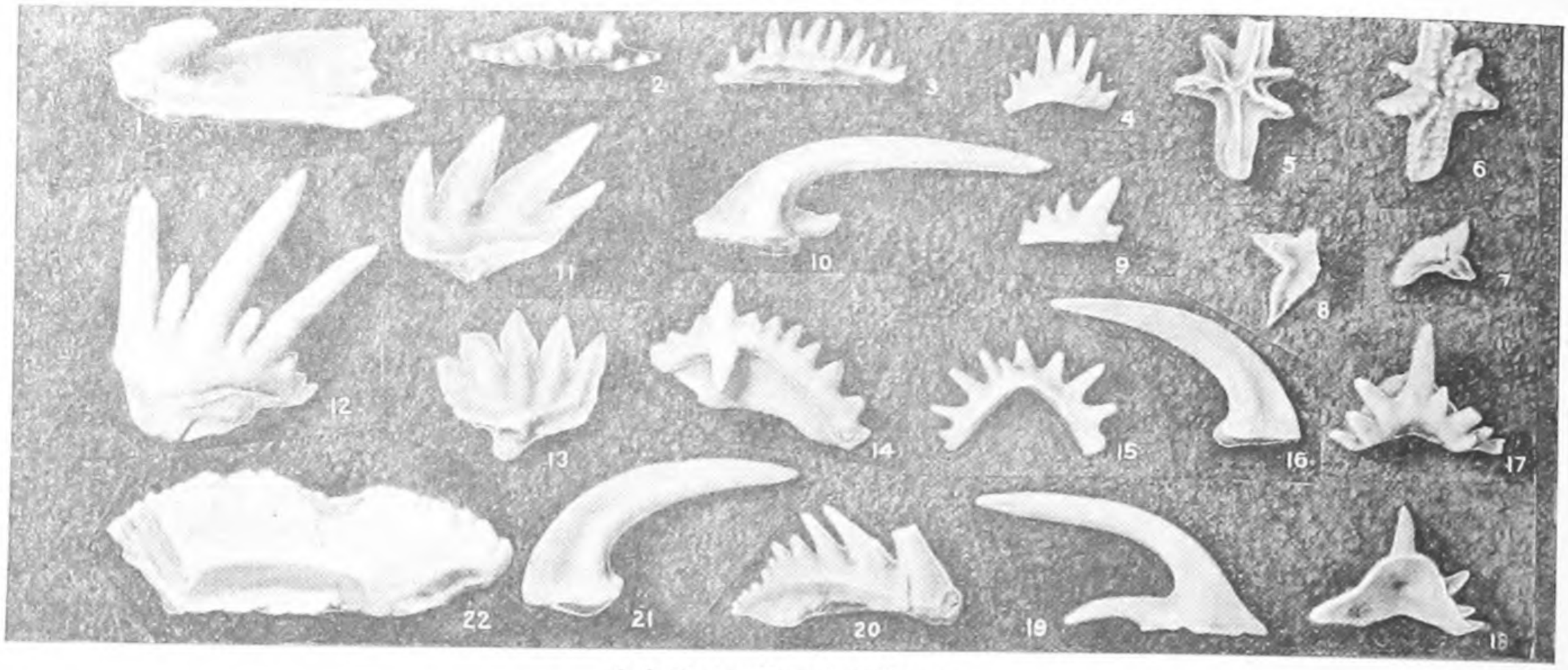
A. ramosa (Stauffer) B and M (**93**—5, 6). **M. Ord.:** Minn. (Decorah), Mo. (Kimmswick).

CARDIODELLA Branson and Mehl 1942

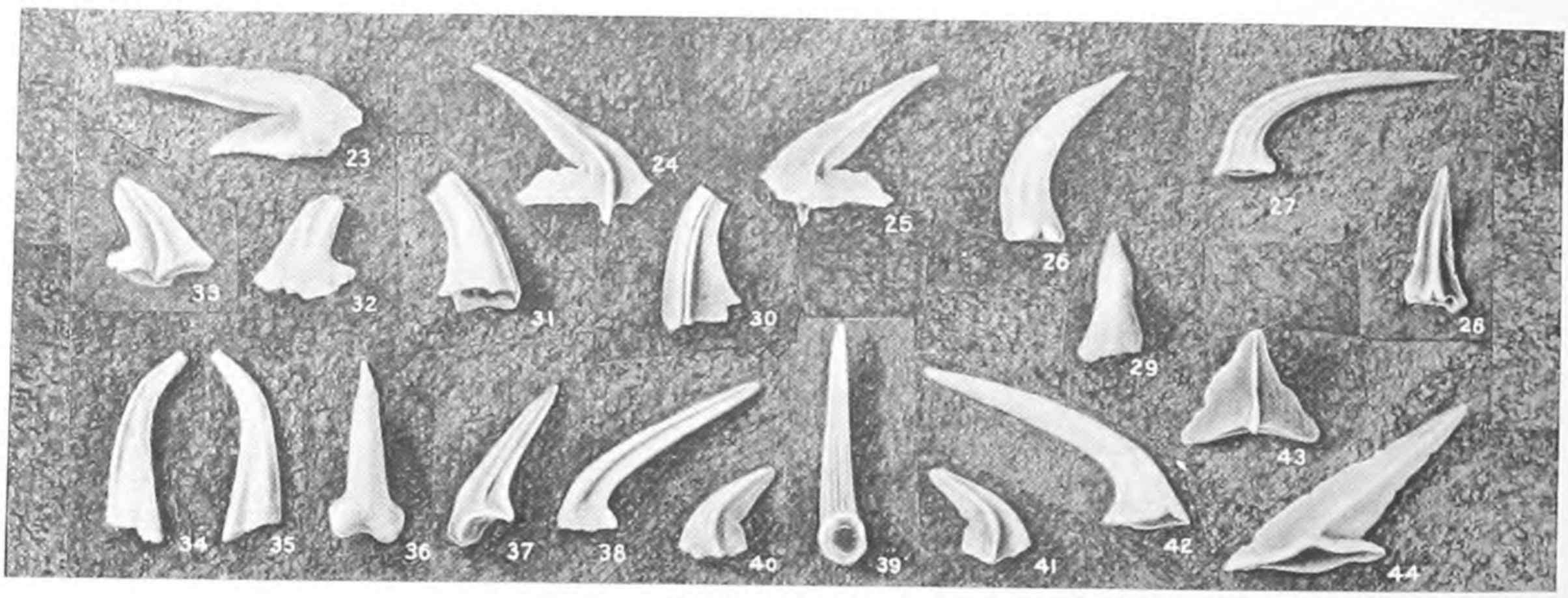
(= CARDIODUS Branson and Mehl 1933)

(**Cardiodus tumidus*). Platelike, flat, or slightly con-

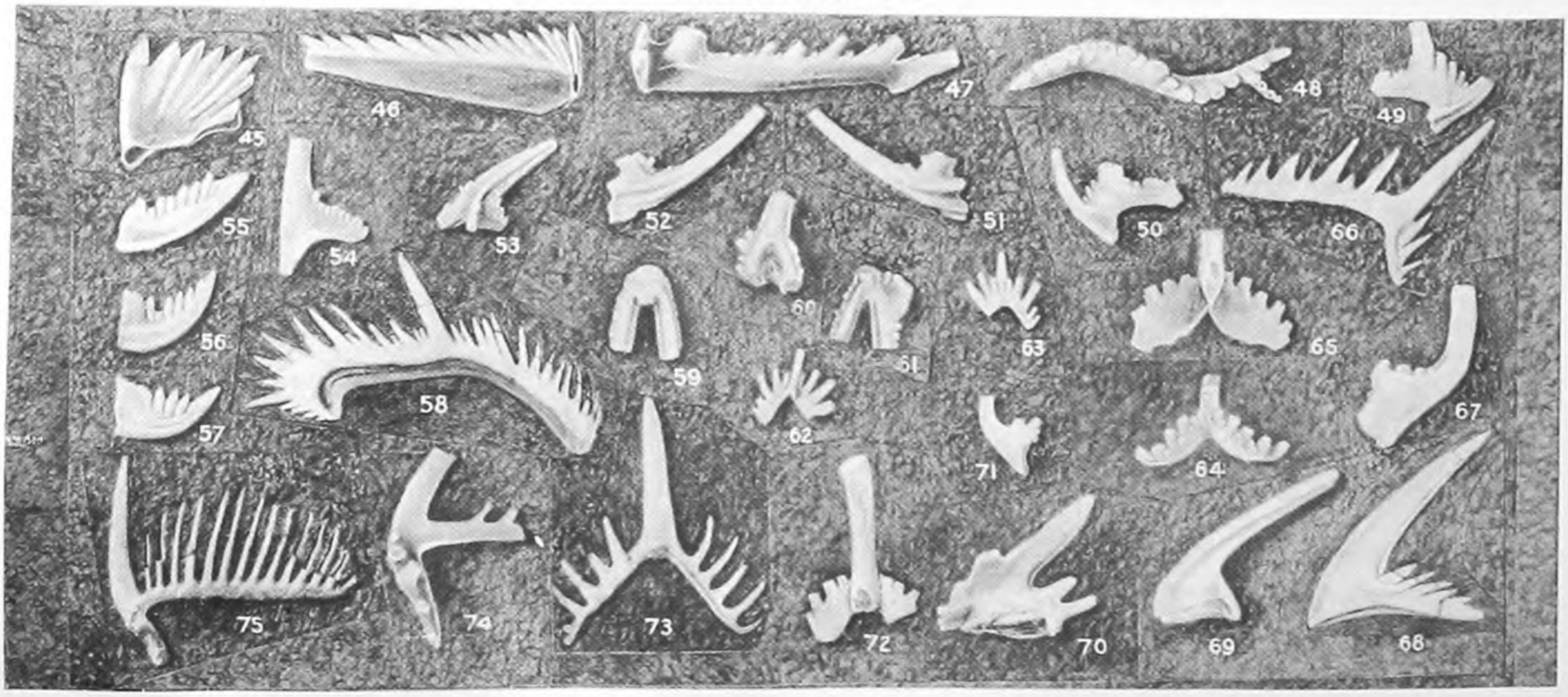
Order Conodontophoridia
Suborder Neurodontiformes
Families
Coleodontidae, Chirognathidae, Trucherognathidae



Sub Order Conodontiformes
Family Distacodidae



Family Prioniodidae



cave dental units; aboral side unexcavated, heart-, crescent-, or arrow-shaped in outline in oral view; discrete divergent denticles. **Ord.** (Mo., Okla.).

***C. tumida** B and M (**93**—17, 18). **M. Ord.:** Mo. (Joachim).

CURTOGNATHUS Branson and Mehl 1933

(**C. typa*). Arched barlike dental units with discrete, divergent subequal denticles; no aboral excavation or pit. **Ord.** (Mo., Okla.).

***C. typa** B and M. **M. Ord.:** Mo. (Joachim).

C. coronata Branson and Mehl (**93**—15). **M. Ord.:** Mo. (Joachim).

POLYCAULODUS Branson and Mehl 1933

(**P. inclinatus*). Bar- or platelike dental units, straight, with discrete slender aligned denticles; aboral side smooth. **Ord.** (Mo., Okla.).

***P. inclinatus** B and M (**93**—9). **Joachim:** Mo.

P. sp. (**93**—4). **Joachim.:** Mo.

TRUCHEROGNATHUS Branson and Mehl 1933

(**T. distorta*). Elongate platelike dental units with a row of slender, discrete, diversely directed denticles; aboral side flat to slightly concave. **Ord.** (Mo., Okla., Colo.).

***T. distorta** B and M (**93**—2, 3). **Joachim:** Mo.

Suborder Conodontiformes [New]. Conodontophoridia with laminated teeth of calcium phosphate.

DISTACODIDAE. Simple recurved cones with deeply excavated base simulating pulp cavity.

ACODUS Pander 1856

(**A. erectus*). Laterally compressed dental units with sharp fore and aft edges; one lateral face smooth, flat to convex; the other produced into a longitudinal ridge or carina. **Ord.** (Minn., Mo.; Europe), **Sil.** (Mo.).

***A. erectus** Pander. **Ord.:** Estonia (Tremadoc).

A. brevis Branson and Mehl (**93**—32, 33). **L. Ord.:** Mo. (Jefferson City).

A. bicostatus Branson and Mehl (**93**—30, 31). **M. Sil.:** Mo. (Bainbridge).

ACONTIODUS Pander 1856

(**A. latus*). Straight or recurved, bilaterally symmetrical dental units; anterior side rounded or broadly angular with smooth lateral faces and concave to keeled posterior side. **Ord.** (Wis., Minn., Ia.; Europe).

***A. latus** Pander; **A.** sp. (**93**—28, 29; see also **93**—43). **Ord.:** Estonia (Tremadoc).

DISTACODUS Hinde 1879

(= MACHAIRODUS Pander 1856)

(**Machairodus romboideus* Pander). Bilaterally symmetrical, laterally compressed dental units with sharp fore and aft edges; lateral faces produced into a longitudinal ridge or keel. **Ord.** (Minn.?, Ia.?, Mo.; Europe).

***D. romboideus** (Pander). **Ord.;** Scotland (Arenig-Llandeilo); Estonia (Tremadoc).

D. sp. (**93**—40, 41). **L. Ord.:** Mo. (Jefferson City).

DREPANODUS Pander 1856

(**D. inflexus*). Bilaterally symmetrical dental units with sharp fore and aft edges and smooth lateral faces. **Ord.** (Ont.; Wis., Minn., Ia., Mo., Okla.; Europe).

***D. inflexus** Pander. **Ord.:** Estonia (Tremadoc).

D. arcuatus Branson and Mehl (**93**—42). **L. Ord.:** Mo. (Jefferson City).

OISTODUS Pander 1856

(**O. lanceolatus*). Fundamentally bilaterally symmetrical dental units, laterally compressed with sharp fore and aft edges; lateral faces smooth, con-

PLATE 93

[Figures are x28, and original by Branson and Mehl, unless otherwise indicated.]

1. Leptochirognathus coalescens. Inner-lateral view. **2, 3. Trucherognathus distorta.** Oral and inner-lateral views. **4. Polycaulodus sp.** Outer lateral view. **5, 6. Amorphognathus ramosa.** Aboral and oral views. **7, 8. Ambalodus triangularis.** Outer-lateral and oral views of two specimens. **9. Polycaulodus inclinatus.** Outer-lateral view. **10. Multioistodus subdentatus.** Inner-lateral view. **11. Leptochirognathus quadrata.** Inner-lateral view. **12. Chirognathus alternata.** Outer-lateral view. **13. Leptochirognathus semifloralis.** Inner-lateral view. **14. Erismodus sp.** Outer-lateral view, attached to jaw. **15. Curtognathus coronata.** Inner-lateral view. **16. Stereoconus gracilis.** Outer-lateral view. **17, 18. Cardiodella tumida.** Oral and aboral views. **19. Multioistodus subdentatus.** Outer-lateral view. **20. Neocoleodus spicatus.** Inner-lateral view, attached to jaw (x11). **21. Stereoconus gracilis.** Inner-lateral view. **22. Coleodus simplex.** Lateral view, clasping jaw. **23. Oistodus lanceolatus.** Inner-lateral view of topotype. **24, 25. Oistodus acuminatus.** Outer- and inner-lateral views. **26. Paltodus arcuatus.** Outer-lateral view. **27. Scolopodus semicostatus.** Lateral view of topotype. **28, 29. Acontiodus sp.** Inner- and outer-lateral views. **30, 31. Acodus bicostatus.** Outer- and inner-lateral views. **32, 33. Acodus brevis.** Inner- and outer-lateral views. **34, 35. Paltodus elegans.** Inner- and outer-lateral views. **36, 37. Ulrichodina sp.** Anterior and lateral views. **38, 39. Scolopodus quadruplicatus.** Lateral and posterior views. **40, 41. Distacodus sp.** Inner- and outer-lateral views. **42. Drepanodus arcuatus.** Lateral view. **43. Acontiodus sp.** Posterior view. **44. Oistodus inaequalis.** Inner-lateral view. **45, 46. Loxodus bransoni.** Lateral views of two incomplete specimens. **47. Hindeodella acuta.** Inner-lateral view. **48. Centrognathodus sinuosus.** Oral view. **49, 50. Phragmodus undulatus.** Outer- and inner-lateral views of two specimens. **51, 52. Belodus gracilis.** Outer- and inner-lateral views of a topotype. **53. Prioniodus elegans.** Lateral view of a topotype. **54. Prioniodus corniger.** Inner-lateral view. **55. Belodus sp.** Outer-lateral view. **56. Belodus compressus.** Inner-lateral view. **57. Belodus sp.** Outer-lateral view. **58. Angulodus demissus.** Lateral view. **59–61. Apatognathus varians.** Aboral, and two oral views of three specimens. **62, 63. Trichognathus delicata.** Posterior and anterior views. **64, 65. Diplodella alternata.** Oral and posterior views. **66. Euprioniodina deflecta.** Lateral view. **67. Cordylodus plattinensis.** Outer-lateral view. **68. Cyrtoniodus complicatus.** Inner-lateral view. **69. Pteroconus gracilis.** Inner-lateral view. **70. Microcoelodus typus.** Posterolateral view. **71. Cordylodus angulatus.** Inner-lateral view. **72. Trichognathus separata.** Posterior view. **73. Hibbardella angulata.** Anterior view. **74. Ligonodina delicata.** Inner-lateral view. **75. Ligonodina pectinata.** Inner-lateral view.

vex to longitudinally ridged; thin lipped basal cup extended posteriorly and laterally at least on one side. **Ord.** (Ont.; Wis., Minn., Ia., Mo., Okla.; Europe).

***O. lanceolatus** Pander (**93**—23). **Ord.:** Estonia (Tremadoc).

O. acuminatus Pander (**93**—24, 25). **Ord.:** Estonia (Tremadoc).

O. inaequalis Pander (**93**—44). **Ord.:** Estonia (Tremadoc).

PALTODUS Pander 1856

(**P. subaequalis*). Bilaterally asymmetrical dental units, anterior side rounded, posterior side sharp or sharply rounded; one lateral face tending toward smooth, the other fluted or grooved. **Ord., Sil.** (Minn., Ia., Mo., Okla.; Europe).

***P. subaequalis** Pander. **Ord.:** Estonia (Tremadoc).

P. arcuatus Stauffer (**93**—26). **M. Ord.:** Minn. (Decorah), Mo. (Kimmswick).

P. elegans Stauffer (**93**—34, 35). **M. Ord.:** Minn. (Decorah), Mo. (Kimmswick).

SCOLOPODUS Pander 1856

(**S. sublaevis* Pander, from the **Ord.** (Tremadoc) of Estonia). Fundamentally bilaterally symmetrical dental units with convex fluted faces. **Ord.** (Wis., Minn., Ia., Mo., Tex.; Europe).

S. semicostatus Pander (**93**—27). **Ord.:** Estonia (Tremadoc).

S. quadruplicatus Branson and Mehl (**93**—38, 39). **L. Ord.:** Wis. (Shakopee), Minn. (Lanesboro, Shakopee), Ia. (Oneota), Mo. (Jefferson City).

ULRICHODINA Furnish 1938

(**U. prima* Furnish, from **L. Ord.** (Shakopee) of Wis.). Dental units similar to *Acontiodus*, with bilateral symmetry, rounded anterior and sharp posterior sides, lower anterior margin extended beyond basal plane and more or less indented. **Ord.** (Wis., Minn., Ia., Mo.).

U. sp. (**93**—36, 37). **L. Ord.:** Mo. (Jefferson City).

PRIONIODIDAE. More or less barlike dental units, originating near anterior end of ramus with a major denticle or fang, erect or posteriorly inclined, at or near the anterior end and in most forms an elongate denticulate posterior extension along oral edge of jaw.

ANGULODUS Huddle 1934

(**A. demissus* Huddle [**93**—58], from **U. Dev.** (New Albany) of Ind.). Dental units similar to *Hindeodella*, but with anterior process and posterior bar subequal; bar and process denticles more nearly discrete than in *Hindeodella* and alternating less in size. **Dev.**

APATOGNATHUS Branson and Mehl 1934

(**A. varians* B and M [**93**—59–61], from **U. Dev.** (Grassy Creek) of Mo.). Sharply arched dental units, asymmetrical with reference to a large apical denticle; limbs connected for a short distance below apex of arch by a thin lamina on one face of the arch. **Dev.**

BELODUS Pander 1856

(**B. gracilis* Pander [**93**—51, 52], from the **Ord.** (Tremadoc) of Estonia). Laterally compressed dental units with cones similar to *Paltodus* with narrow base extending backward (orad); closely spaced peglike denticles rising from posterior edge of cone, nearly parallel with base. **Ord.** (Minn., Mo.; Europe).

B. sp. (**93**—57). **M. Ord.:** Mo. (Kimmswick).

B. compressus Branson and Mehl (**93**—56). **M. Ord.:** Minn. (Decorah), Mo. (Plattin, Kimmswick).

B. sp. (**93**—55). **M. Ord.:** Mo. (Kimmswick).

CENTROGNATHODUS Branson and Mehl 1942

(= CENTROGNATHUS Branson and Mehl 1934)

(**Centrognathus sinuosus*). Denticulate bar with anterior end bent inward and a denticulate spur extending outward from near the bend; denticles subcircular and normally discrete. **Dev.** (Mo.).

***C. sinuosus** (B and M) (**93**—48). **U. Dev.:** Mo. (Grassy Creek).

CORDYLODUS Pander 1856

(**C. angulatus*). Recurved cones with thin-walled, deeply excavated, laterally compressed base; discrete denticles rising from oral edge of base and its posterior extension rather than from cone proper as in *Belodus*. **Ord.** (Minn., Mo.. Kan., Okla.; Europe).

***C. angulatus** Pander (**93**—71). **Ord.:** Estonia (Tremadoc).

C. plattinensis Branson and Mehl (**93**—67). **M. Ord.:** Mo. (Plattin).

CYRTONIODUS Stauffer 1935

(**C. complicatus* Stauffer [**93**—68], from the **M. Ord.** (Glenwood) of Minn.). Laterally compressed cones with thin-lipped, laterally compressed, deeply excavated base that extends posteriorly with inclination slightly below plane of base; posterior bar deeply excavated aborally, oral edge surmounted by backward inclined discrete denticles. **Ord.**

DIPLODELLA Ulrich and Bassler 1926

(**D. bilateralis* U and B, from **U. Dev.** (Chattanooga) of Ala.). Sharply arched denticulate bar, bilaterally symmetrical, apical denticle of large size; a denticulate bar extending posteriorly from base of apical denticle; limb denticles alternating in size and in more than one row. **Dev.** (Ala., Mo.).

D. alternata Branson and Mehl (**93**—64, 65). **U. Dev.:** Mo. (Grassy Creek).

EUPRIONIODINA Ulrich and Bassler 1926

(**E. deflecta* U and B [**93**—66], from **U. Dev.** (Rhinestreet) of N. Y.). Barlike base, sharply arched, with

unequal limbs, large apical denticle directed toward short limb, with separated or closely crowded limb denticles paralleling main denticle. **Sil.?–Penn.** (N. Y., Ind., Ala., Minn., Mo., Okla., Tex.).

HIBBARDELLA Ulrich and Bassler 1926

(**H. angulata* (= *Prioniodus* Hinde)). Sharply arched, bilaterally symmetrical dental units; limb denticles discrete, apical denticle of great length with a denticulate bar extending backward from its base. **Dev.–Penn.** (N. Y., Wyo., Tex.; Canada; Europe).

***H. angulata** U and B (**93**—73). **U. Dev.:** N. Y. (Genesee, Rhinestreet), Ohio (Cleveland).

HINDEODELLA Ulrich and Bassler 1926

(**H. subtilis*). Barlike dental units with large subterminal fang in front of which the bar is bent inward; oral edge closely set with denticles that alternate in size tending to have several small between each two of the larger. **Sil.–Perm.** (Canada; N. Y., Tenn., Minn., Mo., Wyo., Tex.; Europe).

***H. subtilis** U and B. **Dev.:** N. Y. (Genesee), Ohio (Cleveland), Tenn. (Hardin), Mo. (Grassy Creek).

H. acuta Branson and Mehl (**93**—47). **U. Dev.:** Mo. (Grassy Creek).

LIGONODINA Ulrich and Bassler 1926

(**L. pectinata*). Posterior bar with discrete uniform denticles; anterior subterminal fang large, a short denticulate process extending aborally and inward from its base. **Sil.–Perm.** (Ont.; N. Y., Ohio, Minn., Mo., Wyo., Tex.; Europe).

***L. pectinata** U and B (**93**—75). **U. Dev.:** N. Y. (Rhinestreet).

L. delicata Branson and Mehl (**93**—74). **U. Dev.:** Mo. (Grassy Creek).

LOXODUS Furnish 1938

(**L. bransoni*). Bladelike dental units with subequal coalesced posteriorly inclined denticles that decrease in size backward; aboral edge narrowly excavated. **Ord.** (Minn., Ia.).

***L. bransoni** Furnish (**93**—45, 46). **L. Ord.:** Minn. (Blue Earth), Ia. (Oneota).

MICROCOELODUS Branson and Mehl 1933

(**M. typus*). Median part of dental unit recurved, basally expanded, deeply excavated cone, flanked by short, discretely denticulate bars extending laterally from two sides of base. It is possible that this genus should be included under the suborder Neurodontiformes. **Ord.** (Minn., Mo., Okla.).

***M. typus** B and M (**93**—70). **M. Ord.:** Mo. (Joachim).

PHRAGMODUS Branson and Mehl 1933

(**P. primus* B and M, from the **M. Ord.** (Joachim) of Mo.). Dental units sheathlike, on tip of jaw with aboral margin extending anteriorly as a large denticle; oral edge extending posteriorly as a bar with discrete denticles and extending anteriorly as a large denticle, with smooth or denticulate margin between it and antero-aboral denticle. **Ord.** (Minn., Mo., Okla.).

P. undulatus Branson and Mehl (**93**—49, 50). **M. Ord.:** Mo. (Plattin).

PRIONIODUS Pander 1856

(**P. elegans*). Large erect dental units, terminal fang produced antero-aborally with or without vestigial barbs on anterior edge; posterior bar with denticles that tend to coalesce, with but slight excavation beneath fang. **Ord.–Perm.** (N. Y. to Wyo., Minn. to Tex.; Canada; Europe).

***P. elegans** Pander (**93**—53). **Ord.:** Europe (Tremadoc).

P. corniger E. R. Branson (**93**—54). **L. Miss.:** Mo. (Hannibal, Chouteau).

Material from Pander's type locality and formation indicates that the figures and description of the type species, although not correct, are not very misleading. The species is either remarkably variable or the many specimens represent a complete gradation between several species. The mean development consists of a large, laterally compressed denticle which extends aborally from the anterior side of the base in a short denticulate bar; the posterior side extends in a longer denticulate bar, these two limbs forming a laterally curved plane. From the convex side of this curve at the base of the fang extends a short denticulate bar. The trend of the development away from the mean seems to be the reduction and loss of the lateral process and the ultimate fusion of the denticles of the anterior process so that the latter forms the smooth aboral barb of the fang. The acceptance of an atypical species as genotype seems less confusing than drastic change in the taxonomy. No typical representatives of the genus are recorded in American sediments earlier than those of the Silurian.

PTEROCONUS Branson and Mehl 1933

(**P. gracilis* B and M [**93**—69], from the **M. Ord.** (Joachim) of Mo.). Bilaterally asymmetrical recurved cone with deeply excavated, expanded base; small denticles or denticulate process on posterior side of base, denticulate process or denticles originating near anterior side of base and extending laterally; it is possible that this genus should be included in suborder Neurodontiformes. **Ord.** (Minn., Mo., Okla.).

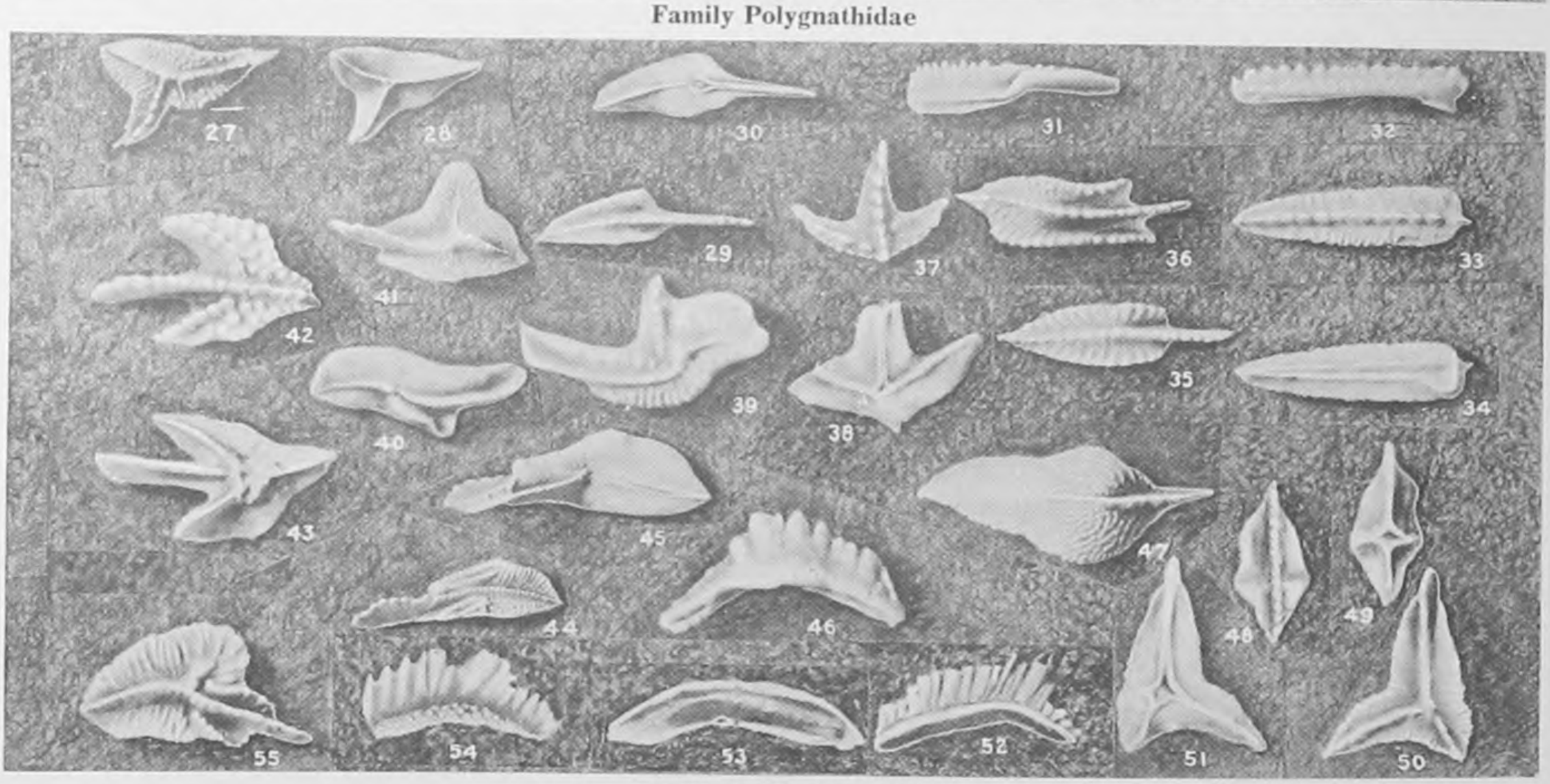
TRICHOGNATHUS Branson and Mehl 1933

(**T. symmetrica* B and M, from the **M. Sil.** (Bainbridge) of Mo.). Large bilaterally symmetrical dental units with deeply excavated expanded base that extends into a posterior and two lateral denticulate bars. **Ord.–Perm.** (Ohio, Minn., Mo., Okla., Wyo.).

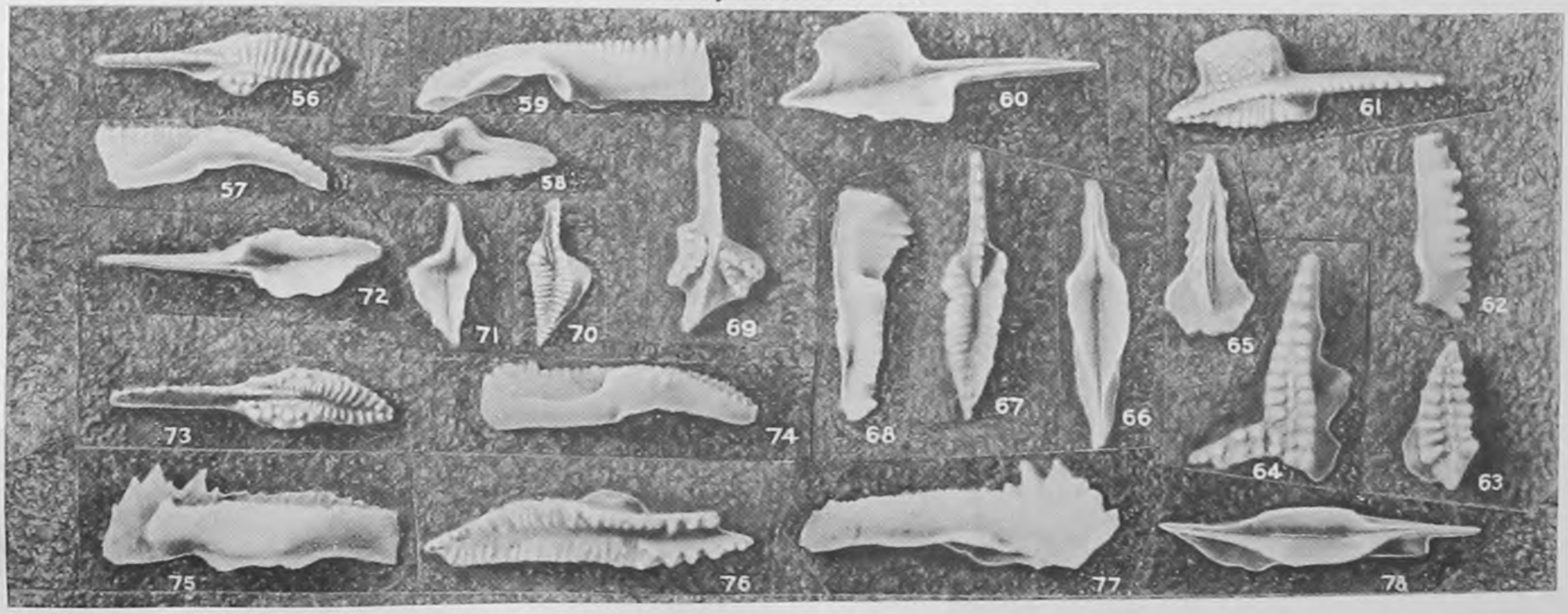
T. sp. (**93**—62, 63). **M. Ord.** Mo. (Kimmswick).

Family Prioniodinidae

Family Polygnathidae



Family Gnathodontidae



T. separata Branson and Mehl (**93—72**). **L. Miss.:** Mo. (Bushberg).

There is some doubt as to whether the younger species referred to this form are of the same genetic trend as the older. The genus differs from *Hibbardella* in that the latter does not have a deep aboral excavation of the terminal denticle.

PRIONIODINIDAE. Dental unit arched, barlike, or bladelike; most forms with an apical denticle, or denticle larger than the others, within middle third of length.

BACTROGNATHUS Branson and Mehl 1941

(**B. *hamata* B and M, from the **Miss.** (Pierson) of Mo.). Narrow platelike or bladelike dental units with posterior end bent laterally; oral surface carinate; aboral surface with cup at juncture of main axis and posterior bend with groovelike extensions along edge. **Miss.** (Mo., Okla., Tex.).

B. excavata Branson and Mehl (**94—13, 14**). **Sycamore:** Okla.

B. angularis Branson and Mehl (**94—15, 16**). **Sycamore:** Okla.

BRYANTODINA Stauffer 1935

(**B. *typicalis* Stauffer [**94—25**], from the **M. Ord.** (Glenwood) of Minn.). Bladelike, arched or straight dental units, denticles only partly fused; apical denticle not differentiated in all specimens; aboral edge excavated. **Ord.**

BRYANTODUS Ulrich and Bassler 1926

(**B. *typicus* U and B, from the **U. Dev.** (Rhinestreet) of N. Y.). Arched denticulate bar, somewhat triangular in cross-section; sharp unexcavated aboral edge except for small subapical pit; apical or superior denticle near midlength; denticles set off from base, tending to fuse. **Dev., Miss.** (Ont.; N. Y., Ohio, Ind., Mo., Ark., Okla.).

B. mundus Branson and Mehl (**94—21**). **L. Miss.:** Mo. (Bushberg).

DICHOGNATHUS Branson and Mehl 1933

(**D. *prima* B and M, from the **M. Ord.** (Harding) of Colo.). Somewhat bladelike dental units with a large denticle at midlength of an arched row of laterally compressed denticles; aboral edge split and considerably expanded laterally at midlength; faces sharply offset laterally at about midlength. **Ord.** (Minn., Mo., Okla., Colo.).

D. typica Branson and Mehl (**94—10**). **M. Ord.:** Mo. (Plattin).

LONCHODINA Ulrich and Bassler 1926

(**L. *typicalis* U and B, from the **U. Dev.** (Rhinestreet) of N. Y.). Arched denticulate bar with limbs subequal and not in same plane; denticles irregular, slender, discrete, not parallel; commonly a large denticle near apex of arch. **Sil.–Perm.** (Canada; N. Y., Ohio, Tenn., Ind., Mo., Okla.).

L. pulchra Branson and Mehl (**94—22**). **U. Dev.:** Mo. (Grassy Creek).

L. separata Branson and Mehl (**94—23**). **U. Dev.:** Mo. (Grassy Creek).

METALONCHODINA Branson and Mehl 1941

(**Prioniodus bidentata* Gunnell = **M. bidentata* (Gunnell) [**94—20**], from the **Penn.** (Cherokee) of Mo.). Dental units similar to *Lonchodina*, with one limb very much abbreviated to retain one exceptionally large denticle followed in some forms by one or two small denticles; appears like *Prioniodus* but has pit under first denticle of long limb. **Miss.–Perm.** (Mo., Okla., Wyo., Tex.).

NOTHOGNATHELLA Branson and Mehl 1934

(**N. *typicalis* B and M [**94—26**], from the **U. Dev.** (Grassy Creek) of Mo.). Arched, more or less bladelike dental units; one limb with short confluent denticles with a lateral shelf on each side at the base, the other limb with large confluent denticles; aboral edge sharp or keeled with small pit at apex of arch. **Dev.** (Ia., Mo.).

PLATE 94

[Figures are x28, and original by Branson and Mehl, unless otherwise indicated.]

1, 2. Spathognathodus spp. 1. S. regularis. Lateral view. **2. S. sulciferus.** Lateral view. **3. Pinacognathodus profundus.** Lateral view. **4–6. Solenodella spp. 4. S. lacerata.** Lateral view. **5. S. fulcrata.** Inner-lateral view. **6. S. bialata.** Inner-lateral view. **7, 8. Oulodus mediocris.** Inner- and outer-lateral views. **9. Subbryantodus arcuatus.** Outer-lateral view. **10. Dichognathus typica.** Outer-lateral view. **11, 12. Pseudopolygnathus prima.** Superior and inferior views of two specimens. **13, 14. Bactrognathus excavata.** Oral and aboral views. **15, 16. Bactrognathus angularis.** Oral and aboral views. **17. Ozarkodina regularis.** Lateral view. **18. Palmatodella delicatula.** Lateral view. **19. Staurognathus cruciformis.** Oral view (x11). **20. Metalonchodina bidentata.** Lateral view. **21. Bryantodus mundus.** Lateral view. **22. Lonchodina pulchra.** Lateral view. **23. Lonchodina separata.** Lateral view. **24. Prioniodina subcurvata.** Lateral view. **25. Bryantodina typicalis.** Lateral view. **26. Nothognathella typicalis.** Inner-lateral view. **27, 28. Ancyrognathus symmetrica.** Oral and aboral views. **29–31. Polygnathus communis.** Oral, aboral, and lateral views. **32–34. Gondolella merrilli.** Lateral, oral, and aboral views. **35. Polygnathus symmetrica.** Oral view. **36. Polygnathus lobata.** Oral view. **37, 38. Scaliognathus anchoralis.** Oral and aboral views of two specimens. **39–41. Palmatolepis spp. 39. P. rugosa.** Oral view. **40. P. glabra.** Oral view. **41. P. subperlobata.** Oral view. **42, 43. Ancyrodella sp.** Oral and aboral views. **44, 45. Siphonodella quadruplicata.** Oral and aboral views of two specimens. **46. Polygnathellus nothus.** Inner-lateral view. **47. Polylophodonta concentrica.** Oral view. **48, 49. Polygnatholdes siluricus.** Oral and aboral views. **50, 51. Doliognathus lata.** Oral and aboral views. **52–54. Polygnathellus typicalis.** Inner-lateral, aboral, and inner-lateral views of three specimens. **55. Siphonodella lobata.** Oral view. **56–58. Idiognathodus delicatus.** Oral, lateral, and aboral views. **59–61. Gnathodus pustulosus.** Inner-lateral, aboral, and oral views. **62–65. Icriodus spp. 62. I. curvatus.** Lateral view. **63. I. expansus.** Oral view. **64. I. latericrescens.** Oral view. **65. I. symmetricus.** Aboral view. **66–68. Taphrognathus varians.** Aboral, oral, and lateral views of three specimens. **69. Gnathodus (Dryphenotus) macrolobatus.** Oral view. **70, 71. Polygnathodella fossata.** Oral and aboral views. **72–74. Streptognathodus spp. 72. S. gracilis.** Aboral view. **73, 74. S. excelsus.** Oral and lateral views. **75–78. Cavusgnathus cristata.** Inner-lateral, oral, outer-lateral, and aboral views.

OULODUS Branson and Mehl 1933

(**O. mediocris* B and M [**94**—7, 8], from the **M. Ord.** (Plattin) of Mo.). Arched and twisted denticulate bar with large denticle at apex of arch; aboral side split and laterally expanded. **Ord.** (Minn., Mo.).

OZARKODINA Branson and Mehl 1933

(**O. typica* B and M, from the **M. Sil.** (Bainbridge) of Mo.). Thin, bladelike, arched dental units; laterally compressed denticles, one of large size at apex, no conspicuous thickening at base of denticles; aboral edge thin, small pit at midlength. **Ord.–Perm.** (Ind., Ia., Mo., Kan., Okla., Tex.).

O. regularis Branson and Mehl (**94**—17). **L. Miss.:** Mo. (Bushberg).

PALMATODELLA Ulrich and Bassler 1926

(**P. delicatula*). Denticulate bar sharply bent, unequal limbs; denticles of long limb inclined toward apex, which is commonly marked by a large denticle; denticles parallel, tending to fuse. **U. Dev., L. Miss.** (Ohio, Ind., Ala., Mo., Okla.).

***P. delicatula** U and B (**94**—18). **U. Dev.:** Ind. (New Albany), Ala. (Chattanooga).

PINACOGNATHUS Branson and Mehl 1942

(= PINACODUS Branson and Mehl 1934)

(**Pinacodus profundus*). Dental units short, deep; comparatively thick blade with sharply crenulate rather than denticulate oral edge; small pit at midlength of aboral edge. **Miss.** (Mo., Okla.).

***P. profunda** (B and M) (**94**—3). **L. Miss.:** Mo. (Bushberg).

PRIONIODINA Ulrich and Bassler 1926

(**P. subcurvata* U and B [**94**—24], from the **U. Dev.** (Rhinestreet) of N. Y.). Dental units moderately arched denticulate bars with equal or unequal limbs; discrete subequal limb denticles; denticle of moderate or large size at apex; denticles subparallel. **Dev.–Penn.** (N. Y. to Kan., Minn. to Tex.).

PSEUDOPOLYGNATHUS Branson and Mehl 1934

(**P. prima* B and M [**94**—11, 12], from the **L. Miss.** (Bushberg, Hannibal) of Mo.). Dental units similar to *Spathognathodus*, with blade thickened over region of aboral cup to produce a transversely ridged platform comparable to *Polygnathus*. **Miss.** (Ind., Mo., Okla., Tex.).

SOLENODELLA Branson and Mehl 1942

(= SOLENOGNATHUS Branson and Mehl 1934)

(**Solenognathus lacerata*). Bladelike, moderately arched dental units with confluent denticles; a lateral flange or shelf on one side for full length of base. **L. Miss.** (Ind., Mo., Okla.).

***S. lacerata** (B and M) (**94**—4), **S. fulcrata** (**94**—5), and **S. bialata** (**94**—6), all described by Branson and Mehl, come from the **L. Miss.** (Bushberg) of Mo.

SPATHOGNATHODUS Branson and Mehl 1941

(= SPATHODUS Branson and Mehl 1933)

(**Spathodus primus*). Dental units nearly straight, bladelike, highest near anterior end; denticles confluent, compressed, thin aboral edge with large, shallow, sharply outlined midlength cup or navel. **Sil.–Perm.** (Ind. to Kan., Ia. to Tex.).

***S. primus** (B and M). **M. Sil.** (Bainbridge): Mo.

S. regularis (**94**—1) and **S. sulciferus** (**94**—2), both described by Branson and Mehl, come from the **L. Miss.** (Chouteau) of Mo.

STAUROGNATHUS Branson and Mehl 1941

(**S. cruciformis* B and M [**94**—19] from the **Miss.** (Sycamore) of Okla.). Dental units barlike with transverse bar in posterior half of length; oral surface nodose on edges rather than denticulate; aboral edge grooved with cup at juncture of bar and crosspiece. **Miss.**

SUBBRYANTODUS Branson and Mehl 1934

(**S. arcuatus* B and M [**94**—9], from the **L. Miss.** (Bushberg, Hannibal) of Mo.). Dental units arched, bladelike, limbs curved so that one side of arch is concave; denticles laterally compressed with one of large size at arch apex; aboral side deeply excavated along limbs. **Miss.** (Mo., Okla.).

POLYGNATHIDAE. Dental units leaflike plates, fundamentally bilaterally symmetrical; a median blade extends forward from plate; aboral surface with a small attachment scar in middle of plate.

ANCYRODELLA Ulrich and Bassler 1926

(**A. nodosa* U and B, from the **U. Dev.** (Rhinestreet) of N. Y.). Dental plate arrow- or heart-shaped; apex at back end, keel with lateral branches from attachment pit along anterolateral lobes. **Dev.** (N. Y., Tenn., Ala., Minn., Ia., Mo., Ark., Okla., Tex., Wyo.).

A. sp. (**94**—42, 43). **U. Dev.:** Ia. (Sweetland Creek).

ANCYROGNATHUS Branson and Mehl 1934

(**A. symmetrica* B and M [**94**—27, 28], from the **U. Dev.** (Grassy Creek) of Mo.). Dental plate somewhat heart-shaped, bifid at the back, keel branching at attachment pit and extending into posterior lobes. **Dev.** (Ind., Minn., Ia., Mo., Okla.).

DOLIOGNATHUS Branson and Mehl 1941

(**D. lata* B and M [**94**—50, 51], from the **L. Miss.** (Pierson) of Mo.). Elongate, platelike dental units with curved axis and a posterolateral process extending from convex side; carina and keel branched and extending into process; resembles *Ancyrognathus*. **Miss.** (Mo., Tex.; Europe).

GONDOLELLA Stauffer and Plummer 1932

(**G. elegantula* S and P, from the **Penn.** (Graford) of Texas). Dental unit a tongue-shaped plate pointed

at front end with sharply denticulate carina; large posterior cup on aboral side extending forward as a grooved keel. **Penn., Perm.** (Ill., Mo., Ark., Kan., Okla., Tex., Wyo.).

G. merrilli Gunnell (**94**—32–34). **Penn.** Mo. (Kansas City).

PALMATOLEPIS Ulrich and Bassler 1926

(**P. perlobata* U and B, from the **U. Dev.** (Hardin) of Tenn.). Dental unit a tongue-shaped plate; axis (made up of carina and keel) laterally sigmoidal; large azygous node in carina near center of plate. **Dev.:** (Canada; N. Y., Ohio, Ind., Ill., Minn., Ala., Mo., Ark., Okla., Tex., Wyo.; Europe).

P. rugosa Branson and Mehl (**94**—39). **U. Dev.:** Mo. (Grassy Creek).

P. glabra Ulrich and Bassler (**94**—40). **U. Dev.:** Ind. (New Albany), Tenn. (Hardin), Ala. (Chattanooga), Mo. (Grassy Creek).

P. subperlobata Branson and Mehl (**94**—41). **U. Dev.:** Ia. (Sweetland Creek).

POLYLOPHODONTA Branson and Mehl 1934

(**P.* (*Polygnathus*) *gyratilineata* Holmes, from the **Dev.** (Chattanooga) of Ala.). Dental unit a lanceolate plate pointed at the back end; oral side transversely and longitudinally convex, covered with concentric ridges. **Dev.** (Ind., Ala., Mo.).

P. (Polygnathus) concentrica Ulrich and Bassler (**94**—47). **U. Dev.:** Mo. (Noel).

POLYGNATHOIDES Branson and Mehl 1933

(**P. siluricus* B and M [**94**—48, 49], from the **M. Sil.** (Bainbridge) of Mo.). Deeply concave oral surface plate without a blade; with a median carina made of sharp, partly discrete denticles. **Sil.**

POLYGNATHELLUS Ulrich and Bassler 1926

(**P. typicalis*). Bladelike dental units with coalescent, sharp, pointed denticles, highest at midlength of series; a lateral flange or shelf on one side of entire length of base. **Sil., Dev.** (N. Y., Ind., Mo.).

***P. typicalis** U and B (**94**—52–54). **U. Dev.:** N. Y. (Rhinestreet).

P. nothus Branson and Mehl (**94**—46). **U. Dev.:** Mo. (Grassy Creek).

POLYGNATHUS Hinde 1879

(**P. dubia* Hinde, from the **U. Dev.** (Genesee) of New York). Dental unit a transversely concave lanceolate plate, carinate, with long free blade; aboral pit near center. **Dev., Miss.** (Canada; N. Y., Ohio, Ind., Ky., Tenn., Ill., Ia., Mo., Ark., Okla., Kan., Tex., Wyo.; Europe.).

P. communis Branson and Mehl (**94**—29–31). **L. Miss.:** Mo. (Chouteau).

P. symmetrica E. R. Branson (**94**—35). **L. Miss.:** Mo. (Chouteau).

P. lobata Branson and Mehl (**94**—36). **L. Miss.:** Mo. (Chouteau).

SCALIOGNATHUS Branson and Mehl 1941

(**S. anchoralis*). Pick- or anchor-shaped dental units with pointed termini; back end convex or straight; long axis and posterior transverse bars carinate; keel with median groove branched at pit at union of axis and transverse branches; much like *Ancyrodella*. **Miss.** (Mo., Okla., Tex.; Europe).

***S. anchoralis** B and M (**94**—37, 38). **L. Miss.:** Mo. (Pierson), Okla. (Welden).

SIPHONODELLA Branson and Mehl 1942

(= SIPHONOGNATHUS Branson and Mehl 1934)

(**Siphonognathus duplicata*). Dental units similar to *Polygnathus*, with front end of plate produced into a spout. **Miss.** (Ind., Mo., Kan., Okla., Tex.).

***S. duplicata** (B and M). **L.** and **M. Miss.:** Ind. (basal Rockford), Mo. (Bushberg, Hannibal), Okla. (Welden).

S. quadruplicata Branson and Mehl (**94**—44, 45). **L. Miss.:** Mo. (Bushberg).

S. lobata Branson and Mehl (**94**—55). **L. Miss.:** Mo. (Bushberg).

GNATHODONTIDAE [New]. Elongate, platform- or troughlike dental units with an anterior blade; broadly excavated aborally.

CAVUSGNATHUS Harris and Hollingsworth 1933

(**C. alta* H and H, from the **U. Miss.** (Caney) of Okla.). Elongate platform with median trench, one lateral margin of which extends anteriorly as blade. **Miss.–Perm.** (Mo., Okla., Wyo.).

C. cristata Branson and Mehl (**94**—75–78). **Miss.:** Okla. (Caney).

GNATHODUS Pander 1856

(**G. mosquensis* Pander, from the **Miss.** (Bergkalk) of U. S. S. R.). Dental units cuplike, with oral surface convex and medially traversed by carina which extends into anterior blade; oral ornamentation of cup tending to radial. **Miss., L. Penn.?** (Mo., Okla., Tex.; Europe).

G. pustulosus Branson and Mehl (**94**—59–61). **U. Miss.:** Okla. (Caney).

G. (Dryphenotus) macrolobatus Cooper (**94**—69). **M. Miss.:** Okla. (Welden).

ICRIODUS Branson and Mehl 1934

(**I. alternatus* B and M, from the **U. Dev.** (Grassy Creek, Snyder Creek) of Mo.). Dental units typically lachrymiform in outline, without blade; no distinct carina; entire aboral surface excavated. **Dev.** (N. Y. to Wyo., Minn. to Tex.; Europe).

I. curvatus Branson and Mehl (**94**—62). **U. Dev.:** Ill. (Grassy Creek), Ia. (Sweetland Creek), Mo. (Grassy Creek).

I. expansus Branson and Mehl (**94**—63). **U. Dev.:** N. Y. (Genundewah), Mo. (Snyder Creek, Mineola).

I. latericrescens Branson and Mehl (**94**—64). **M. Dev.:** Ind. (Jeffersonville), Mo. (Mineola).

I. symmetricus Branson and Mehl (**94**—65). **U.**

Dev.: Mo. (Grassy Creek, Louisiana), Ark. (Sylamore).

IDIOGNATHODUS Gunnell 1931

(**I. claviformis* Gunnell, from the **L. Penn.** (Des Moines) of Mo.). Dental units fundamentally bilaterally symmetrical, median blade traceable on platform as suppressed carina; oral surface of platform cross ridged, not longitudinally grooved. **Penn., Perm.** (Mo. to Wyo., Okla. to Tex.).

I. delicatus Gunnell (**94**—56–58). **Penn.** Mo. (Kansas City).

POLYGNATHODELLA Harlton 1933

(**P. ouachitensis* Harlton, from the **Penn.** (Johns Valley) of Okla.). Dental units bilaterally asymmetrical; oral surface of elongate platform flat, cross ridged, outer side produced into a blade. **Penn.** (Mont., Wyo., Okla.).

P. fossata Branson and Mehl (**94**—70, 71). **Penn.** Wyo. (Hartville).

STREPTOGNATHODUS
Stauffer and Plummer 1932

(**S. elegantulus*). Dental units bilaterally symmetrical, platform elongate, medially trenched; blade continued as faint carina in trench. **Penn., Perm.** (Mo., Okla., Tex., Wyo.).

***S. elegantulus** S and P. **Penn.:** Mo. and Kan. (Des Moines, Missouri, and Virgil series), Okla. (Pawhuska), Tex. (Graford, Mineral Wells).

S. excelsus Stauffer and Plummer (**94**—73, 74). **Penn.:** Mo. (Cherokee, Pleasanton, Henrietta, Kansas City, Lansing), Tex. (Graford).

S. gracilis Stauffer and Plummer (**94**—72). **Penn.:** Mo. (Kansas City), Tex. (Graford, Mineral Wells).

TAPHROGNATHUS Branson and Mehl 1940

(**T. varians* B and M [**94**—66–68], from the **M. Miss.** (Keokuk) of Mo.). Bilaterally symmetrical, elongate, medially trenched platform with median blade; much like *Streptognathodus*. **Miss.**

CHAPTER VIII

PHYLUM BRYOZOA (POLYZOA)[1,2]

The Bryozoa are small, composite, usually marine, and intensely colonial animals which secrete about themselves an external protective and supporting structure, the *zooecium*, which is boxlike or tubular and composed of membranous, gelatinous, chitinous, or calcareous material. The zooecia are joined together in many ways to form a wide variety of colonial structures known as *zoaria* (singular, *zoarium*). Very commonly zoaria incrust shells, stones, or other bodies and, if such incrustations are superposed, the result is a hemispherical, globular, nodular or irregular mass, often of considerable size. Again zoaria may grow as fronds and branching stems with meshwork or dendroidal structure. Most zoaria are attached to extraneous objects either by the base or by the greater part of their under surface, or they are moored to the bottom by rootlike structures. In some forms the zoarium is jointed, resulting in greater mobility.

The colony which develops the zoarium arises from a single larva which has developed during a free-swimming period before it settles down to become a sessile benthos. Immediately upon its attachment, this larva secretes a covering known as the *protoecium*, after which it disintegrates and then develops into a typical individual or *polypide*. This polypide, the first of the colony, then secretes about itself and around the opening into the protoecium a tubular structure, the *ancestrula*, which represents the first zooecium of the zoarium. Repeated budding

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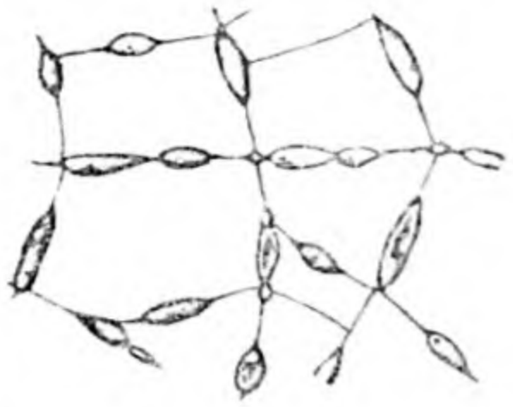
[2] **Bassler, R. S.,** The bryozoan fauna of the Rochester shale: *USGS*, B 292: 1–136, pl 1–31, 1906; Bryozoa of the Middle Devonic of Wisconsin: *Wis G S*, B 21: 49–67, il, 1911; The Bryozoa or moss animals: *Smith Inst*, An Rp 1920: 339–380, il, 1922; Bryozoa [in **Twenhofel's** Geology of Anticosti Island]: *CGS*, M 154: 143–168, il, 1927; Bryozoa, generum et genotyporum, index et bibliographie: *Fos Cat*, pars 67: 1–229, 1935; The Hederelloidea, a suborder of Paleozoic cyclostomatous Bryozoa: *USNM*, Pr 87 (3068): 25–91, il, 1939. **Canu, F.,** and **Bassler, R. S.,** North American early Tertiary Bryozoa: *USNM*, B 106: 1–878, pl 1–162, 1920; North American later Tertiary and Quaternary Bryozoa: *USNM*, B 125: 1–302, pl 1–47, 1923; The bryozoan fauna of the Vincentown [Eocene] limestone: *USNM*, B 165: 1–108, pl 1–21, 1933. **Condra, G. E.,** The Coal Measure Bryozoa of Nebraska: *Neb G S*, B 2: 11–163, il, 1903. **Condra, G. E.,** and **Elias, M. K.,** *Fenestella* Lonsdale and *Fenestrellina* d'Orbigny: *JP* 15: 565–566, 1941. **Coryell, H. N.,** Bryozoan faunas of the Stones River group of central Tennessee: *Ind Ac Sc*, Pr 1919: 261–340, il, 1921. **Cumings, E. R.,** Development of some Paleozoic Bryozoa: *AJS* (4) 17: 49–78, il, 1904; Description of the Bryozoa of the Salem [Mississippian] limestone: *Ind G S*, An Rp 30: 1274–1296, il, 1906; Stratigraphy and paleontology of the Cincinnati series of Indiana: Idem 32: 605–1188, il, 1908. **Cumings, E. R.,** and **Galloway, J. J.,** Stratigraphy and paleontology of the Tanner's Creek section of the Cincinnati series of Indiana: *Ind G S*, An Rp 37: 353–478, il, 1913; Studies of the morphology and histology of the Trepostomata or monticuliporoids: *GSA*, B 26: 349–374, il, 1915. **Deiss, C. F.,** Description and stratigraphic correlation of the Fenestellidae from the Devonian of Michigan: *U Mich Mus Pal*, Contr 3: 233–275, il, 1932. **Duncan, Helen,** Trepostomatous Bryozoa from the Traverse group of Michigan: Idem, Contr 10: 171–270, il, 1939. **Elias, M. K.,** Stratigraphic significance of some late Paleozoic fenestrate bryozoans: *JP* 11: 306–334, 1937. **Fenton, C. L.** and **M. A.,** Stratigraphy of the Hackberry stage of the upper Devonian: *U Mich Mus Pal*, Contr 1: 1–260, il, 1924. **Foerste, A. F.,** Flint Ridge Bryozoa: *DUB, JSL* 2: 71–88, 1887. **Fritz, M. A.,** Permian Bryozoa from Vancouver Island: *R Soc Can*, Tr 26: 93–109, il, 1932. **Hall, James,** Paleontology of New York I and II, 1847, 1852; Fauna of the Niagara group in central Indiana: *N Y St Mus*, An Rp 28: 99–203, il, 1876–1879; Descriptions of Fenestellidae of the Hamilton of New York: *N Y St G*, An Rp 6: 41–70, il, 1887. **Hall, James,** and **Simpson, G. B.,** Paleontology of New York VI, 1887. **Loeblich, A. R.,** Bryozoa from the Ordovician Bromide formation, Oklahoma: *JP* 16: 413–436, il, 1942. **McFarlan, A. C.,** Chester Bryozoa of Illinois and western Kentucky: *JP* 16: 437–458, il, 1942. **McGuirt, J. H.,** Louisiana Tertiary Bryozoa: *La G S*, GB 21: 1–177, pl 1–31, 1941. **McNair, A. H.,** Cryptostomatous Bryozoa from the Traverse of Michigan: *U Mich Mus Pal*, Contr 5 (9): 103–170, il, 1937; Devonian Bryozoa from Colombia: *B Am Pal* 25 (93): 1–34, il, 1940; Upper Devonian Bryozoa: *JP* 16: 343–350, il, 1942. **Moore, R. C.,** A bryozoan faunule from the Upper Graham formation, Pennsylvanian, of north-central Texas: *JP* 3: 1–27, 121–156, il, 1929; New species of bryozoans from Pennsylvanian of Texas: *DUB, JSL* 25: 147–163, il, 1930. **Nicholson, H. A.,** Structure and affinities of *Monticulipora* and its subgenera, Edinburgh, 1881, p 1–240, il [Reviewed in *An Mag N H* 5 (8): 61–63, 1881]. **Nickles, J. M.,** and **Bassler, R. S.,** A synopsis of American fossil Bryozoa, including bibliography and synonymy: *USGS*, B 173: 1–663, 1900. **Parks, W. A.,** and **Dyer, W. S.,** Stratigraphy and paleontology of Toronto and vicinity, Pt II, Molluscoidea: *Ont Dp Min*, An Rp 30: 1–46, il, 1922. **Simpson, G. B.,** Handbook of genera of North American Palaeozoic Bryozoa: *N Y St G*, An Rp 14: 407–608, il, 1897. **Ulrich, E. O.,** American Palaeozoic Bryozoa: *Cin Soc NH*, J 5, 6, 7, il, 1882–1884; Palaeozoic Bryozoa: *Ill GS* 8: 285–688, il, 1890; Lower Silurian [Ordovician] Bryozoa of Minnesota: *Minn G S* 3 (1): 96–332, pl 1–28, 1893. **Ulrich, E. O.,** and **Bassler, R. S.,** A revision of the Palaeozoic Bryozoa, Pt I, on genera and species of Ctenostomata: *SMC* 45: 256–294, il, 1904; Pt II, on genera and species of Trepostomata: *SMC* 47: 15–55, il, 1904; Bryozoa of the middle and lower Devonic deposits of Maryland: *Md G S, L Dev:* 259–290, il, 1913: *U Dev:* 123–124, il, 1913. **Ulrich, E. O.,** and **Ruedemann, R.,** Are the graptolites bryozoans?: *GSA*, B 42: 589–603, 1931.



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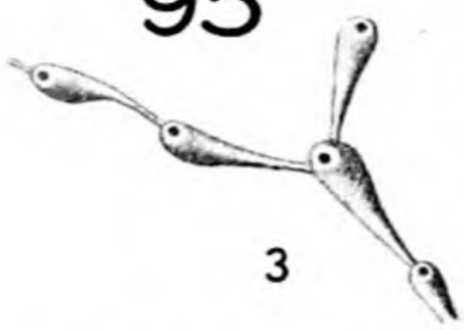

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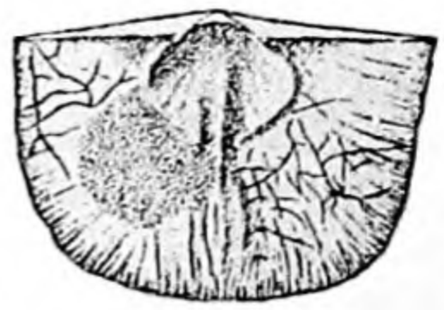

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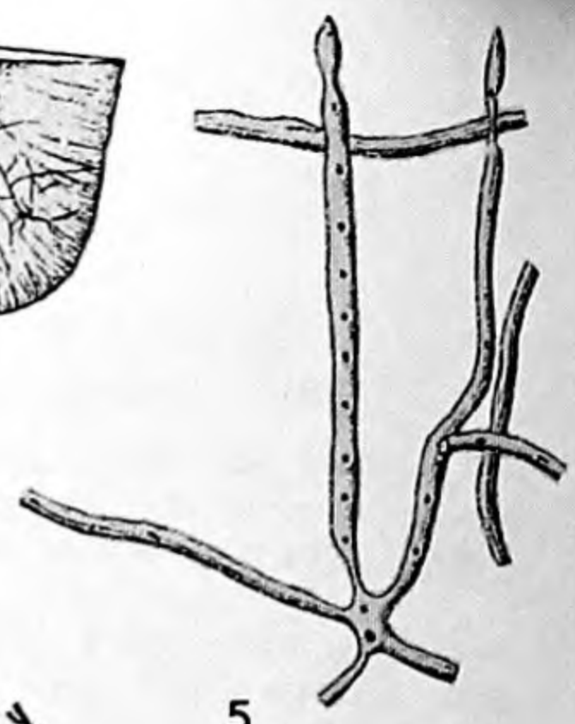

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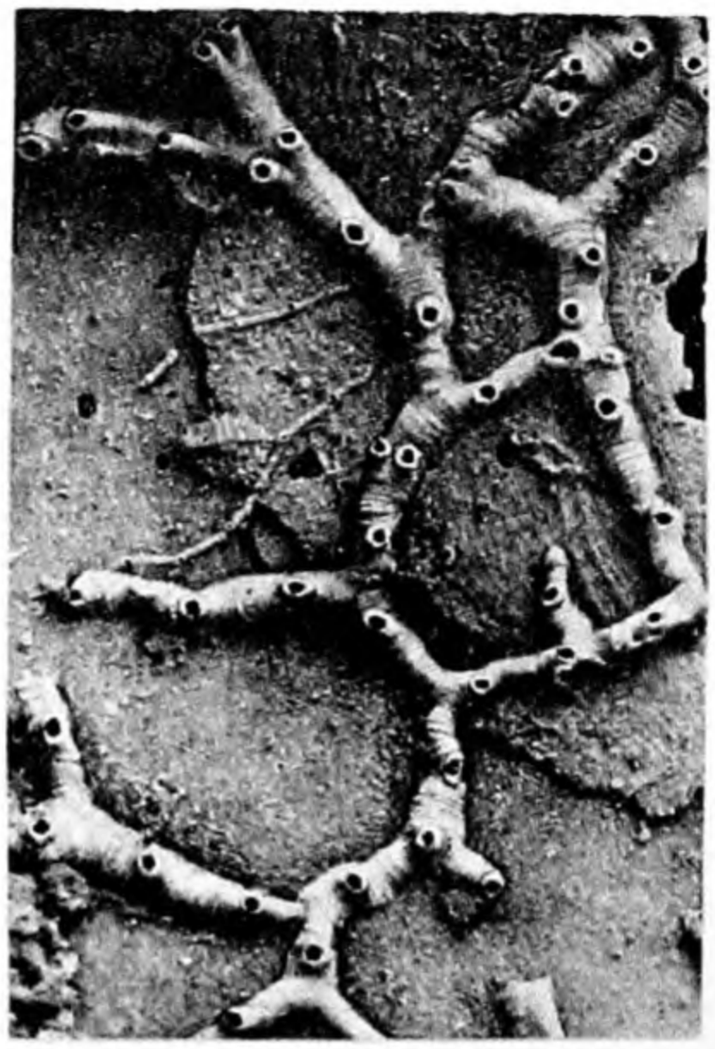

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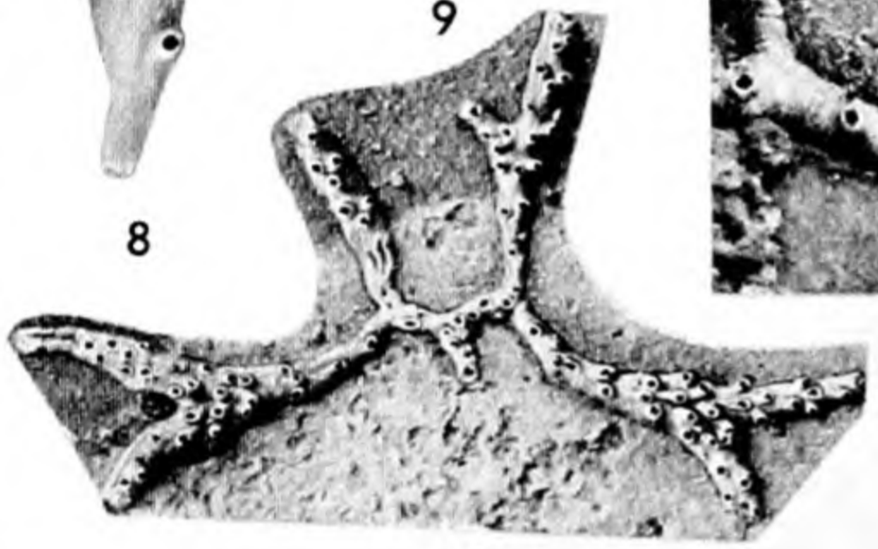

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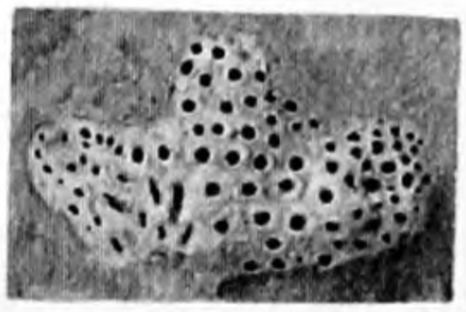

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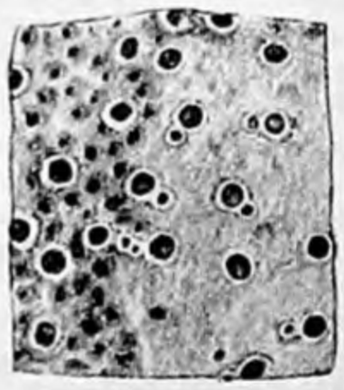

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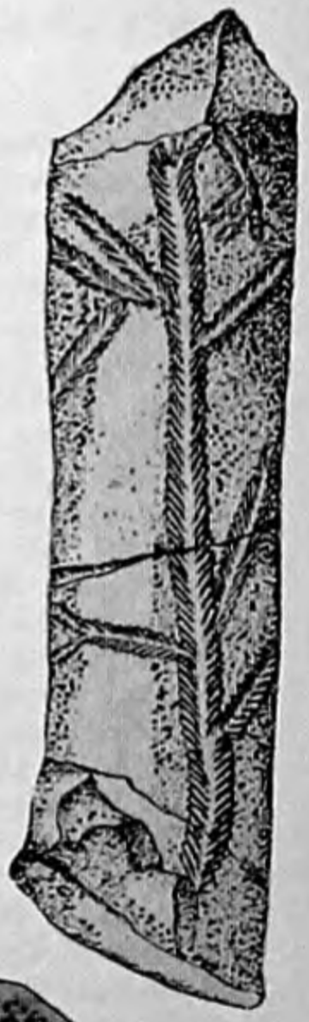

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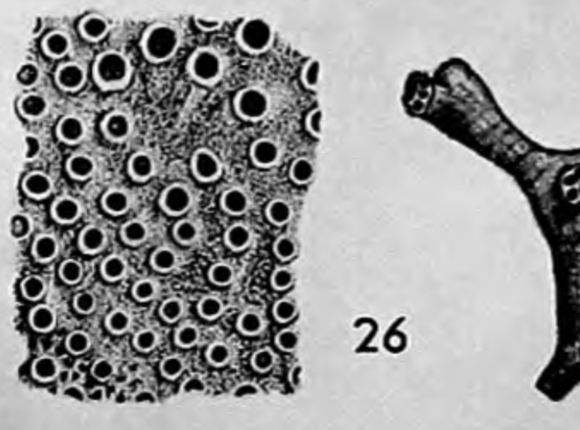

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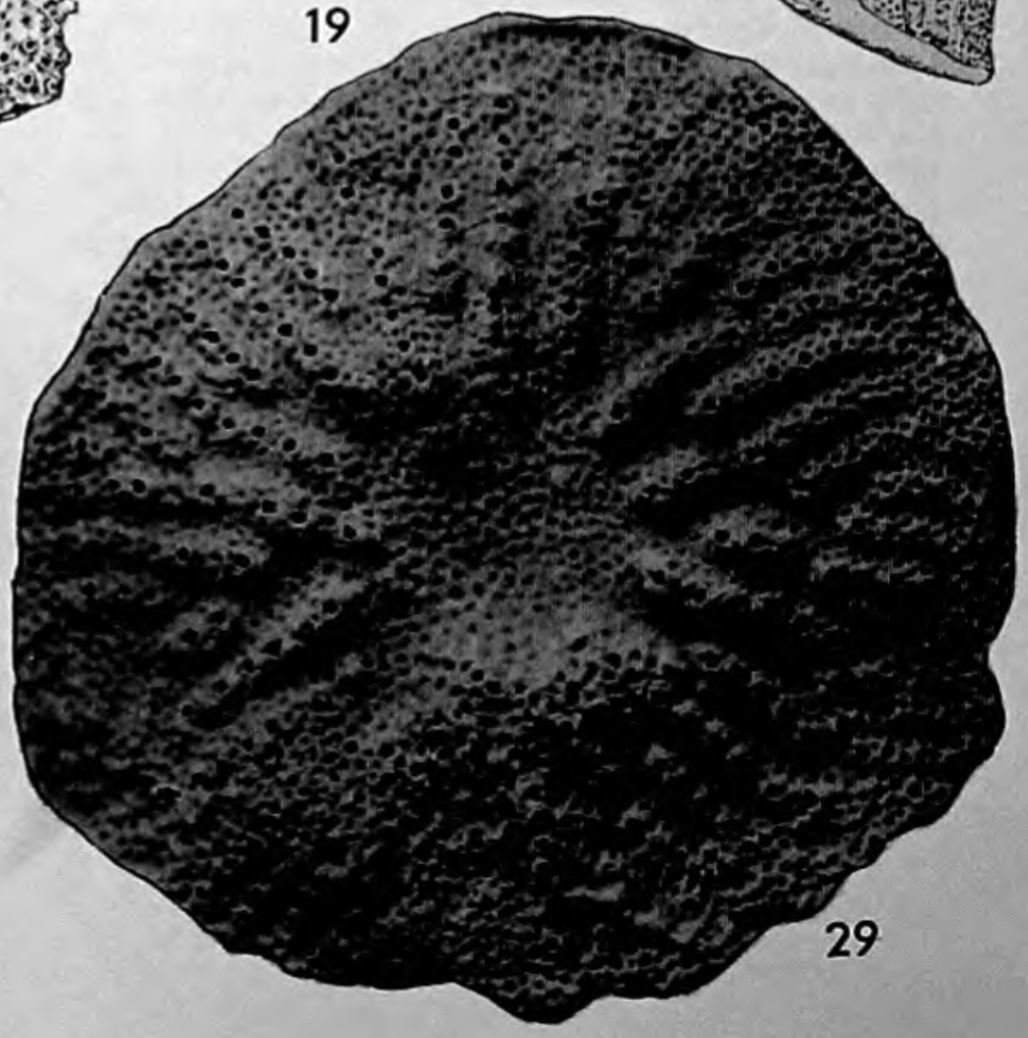

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from the ancestrula at first, and from polypides later, results in the many types of zoaria found among bryozoans.

Frondlike zoaria are commonly incrusting or protected with a basal epitheca. They may be *unilaminar* (e.g. *Lichenalia*), with zooecial openings or apertures on one side only, and if the sides of such fronds unite, a hollow tube lined with epitheca is produced. They may also be *bilaminar* or *bifoliate* (e.g. *Meekopora*), with the epitheca of the two parts growing together to constitute the *mesotheca*, which often contains median *tubuli*. In zoaria with fenestrated or meshwork architecture, the branches may anastomose or they may be straight and roughly parallel; in the latter case they are united at intervals by cross bars (*dissepiments*) which may or may not bear zooecial apertures. The zooecia in such zoaria may lie along the borders of the branches, arranged symmetrically with respect to numerous surface ornamentational structures (nodules, spines, carinae, etc.), or they may have random distribution over the surface. In many forms the branches have a median longitudinal keel or *carina* which may be sharp, rectangular, or even bear a complicated superstructure. In *Archimedes* the fronds of the zoarium are twisted about an axis along a helical spiral; the fronds are easily broken away, however, and the fossilized zoarium as a rule is represented only by the solid axis.

Zooecia may be superficial or deep. If deep, the portion near the surface is designated the *mature region* and the inner or axial part, the *immature region*. In bryozoans with deep zooecia the walls (sometimes designated the *frontal*) surrounding the true aperture are buried and only the upper part of the frontal appears at the surface. *Costules* are hollow bars within the zooecial wall, and the hollow itself is designated the *lumen* or *lumen line*; rounded openings between bordering costules are *lacunae*—lateral if at the sides and median if at the end. *Septulae* (rarely visible in fossils) are small pores uniting adjacent zooecia; these commonly open into small chambers called *dietellae*, which may be seen in some thick-walled forms by abrading the frontal.

Paleozoic genera often have the zooecial apertures surrounded by an elevated rim or *peristome*, and in some there was a lid or *operculum* closing the aperture. Often a portion of the posterior wall is more or less thickened and curved to a shorter radius, forming *lunaria*, the ends of which may project into the zooecium as *pseudosepta*. At the junction of the apertures, small cylindrical tubules (*acanthopores*) may project as spines. If the zooecia are crowded and thin-walled, their apertures are generally polygonal; if thick-walled or separated by interspaces, apertures are circular or oval. Interspaces may be occupied by smaller tubes, the *mesopores*, or by vesicular material. Mesopores are scattered or clustered. Elevations (*monticules*) and flattened or depressed areas (*maculae*) are characteristic surface features, and may be solid or perforated by zooecial apertures (which generally are somewhat larger than normal) or by mesopores.

The zooecia in most Paleozoic genera are divided into chambers by tabular plates (*diaphragms*), or by curved plates (*cystiphragms*), as in the **Trepostomata.** Diaphragms may be complete or pierced by a central opening. In the **Cryptostomata** additional plates, the *hemisepta*, project from the wall into the zooecium. If they project from the posterior wall, they are designated superior; if from the anterior, inferior. In the **Cheilostomata** the wall may be only partly calcified, and hence in fossil forms the zooecial apertures are very large. Two specialized organs of doubtful function are characteristic of the zooecia in this order: the *avicularium*, which is a peculiar structure resembling a bird's head that displays a snapping action; and *vibracula*, which are bristlelike appendages that are almost constantly in motion.

Many bryozoans have *ovicells* (*ooecia*) which are specialized receptacles for the eggs. In some genera zooecia are inflated to form *gonocysts*; in others special zooecia (*gonoecia*) are modified for reproductive purposes.

The Bryozoa are divided into the following classes and orders:

Class **Entoprocta**. Includes very few forms and has left no known fossil record.

Class **Ectoprocta.** Includes fresh-water and marine forms; the latter have left a good record containing many important index fossils.

- Order **Ctenostomata** (living, with few fossils).
- Order **Cyclostomata** (living, with many fossils).
- Order **Trepostomata** (extinct, Paleozoic, with many species).
- Order **Cryptostomata** (extinct, Paleozoic, with many species).
- Order **Cheilostomata** (Mesozoic–Recent, with many fossils).

Order Ctenostomata. Zooecia gelatinous or chitin-

PLATE 95

[Figures are x1 and after Ulrich [CSNH, J 5–7; Ill G S 8; Minn G S 3 (1)] or Canu and Bassler [USNM, B 106, 125] unless otherwise indicated.]

1. Rhopalonaria venosa (x9). **2. Ascodictyon stellatum** (x18). **3. Corynotrypa delicatula** (x12). **4, 5. Vinella repens.** Two zoaria attached to a brachiopod shell, and portion of one enlarged (x18). **6–8. Crisia hörnesi** (x25). An ovicelled segment; dorsal and frontal views. **9. Allonema fusiforme** (x9). **10. Stomatopora pratti** (x6). **11. Hederella filiformis** [Pal N Y 6]. **12. Diastoporina flabellata** (x0.5, x3.5). **13–15. Proboscina** spp. **13. P. clavatula** (x6). **14. P. frondosa** (x9). **15. P. admota** (x12). **16, 17. Berenicea minnesotensis** (x0.5, x9). **18, 19. Partretocycloecia dumosa** (x9, x20). **20, 21. Reptaria stolonifera** [Pal N Y 6]. Zoarium attached to a cephalopod shell; portion enlarged (x6). **22. Entalophora proboscidea** (x12). **23, 24. Crisisina triforata** (x1, x12). **25. Hernodia humifusa** [Pal N Y 6]. **26. Diaperoecia varians** (x12). **27, 28. Filifascigera megaera** (x12). **29. Lichenopora grignonensis** (x12). An entire zoarium.

ous, with comblike processes closing the aperture when tentacles are retracted; zooecia frequently isolated, budding from internodes of tubular stolon, and sometimes appearing as excavations in the host. **Ord.–Recent.**

RHOPALONARIA Ulrich 1879

(**R. venosa*). Zoarium sunken for about half its mass into the object on which it grows (generally a coral, crinoid stem, or shell), and usually preserved only as threadlike excavations in surface of this object, often filled with clay; zooecia unknown. **Ord.–Miss.**

***R. venosa** Ulrich (**95**—1). Zoarium consists of delicate fusiform cells connected by slender stolons of average length of cells; branching irregularly; pinnate or sometimes netlike; excavated in corals, shells, etc. **U. Ord.** (Richmond): Ohio, Ind., Ky.

R. tenuis Ulrich and Bassler. Like preceding, but with fusiform cells narrower and longer, and connecting stolons shorter. **M. Dev.** (Hamilton): Ont.; N. Y., Md., Mich.

ASCODICTYON
Nicholson and Etheridge 1877

(**A. stellatum*). Attached to shells and other objects; consisting of ovate or pear-shaped vesicles in clusters or singly, and arranged along delicate hollow threads or stolons; zooecia unknown. **Sil.–Miss.**

***A. stellatum** N and E (**95**—2). Vesicles calcareous, generally in clusters of six or more (sometimes fewer) cells, averaging nearly 1 mm in diameter, and connected by filamentous tubes. **M. Dev.** (Hamilton): Ont.; N. Y., Mich., Wis.

VINELLA Ulrich 1890

(**V. repens*). Attached to shells, crinoid stems, etc., and consisting of very slender tubular stolons arranged in more or less distinct manner, each marked in perfect specimens by a single row of pores. **Ord., Sil.**

***V. repens** Ulrich (**95**—4, 5). Radial arrangement imperfect; stolons often bifurcating. **M. Ord.** (Black River–Decorah): Minn.; Estonia.

ALLONEMA Ulrich and Bassler 1904

(**A. botelloides*). Attached, sausagelike strings of vesicles with minutely punctate surfaces and a large pore towards one end. **Sil.–Penn.**

A. fusiforme (Nicholson and Etheridge) (**95**—9). Fusiform, sometimes ovate zooecia, isolated or joining one another. **M. Dev.** (Hamilton): Ont.; N. Y., Mich., Ohio (Onondaga), Wis.

Order Cyclostomata. Zooecia simple calcareous tubes, usually without transverse partitions, single or in association; apertures uncontracted and without opercula; ovicell, when present, an enlarged zooecium or an inflation of zoarial surface. **Ord.–Recent.**

CRISIA Lamouroux 1812

(**Sertularia eburnea* Linnaeus). Articulated segments, biserial with three to many zooecia on each. **Eoc.–Recent.**

C. hörnesi Reuss (**95**—6–8). Segment with 16 to 17 tubes; interapertural distance never greater than zoarial width. **Eoc., Olig.** (Jackson, Vicksburg): Ala., Miss. **Eoc.–Mioc.:** Europe.

STOMATOPORA Bronn 1825

(**Alecto dichotoma* Lamouroux). Incrusting, branching zoaria, composed of uniserial subtubular zooecia with circular apertures. **Ord.–Recent.**

S. pratti Canu and Bassler (**95**—10). Zoarium of irregular polygons with tubes wide and wrinkled transversely. **Eoc.:** N. C. (Jackson).

CORYNOTRYPA Bassler 1911

(**Hippothoa delicatula* James). Like *Stomatopora*, but each zooecium constricted to form club-shaped outline. **Ord.–Penn.**

***C. delicatula** (James) (**95**—3). Pear-shaped zooecia, often forming crowded clusters; **C. inflata** (Hall), which occurs with this species, has shorter and stouter zooecia. **M.** and **U. Ord.** (Stones River–Richmond): Eastern and central N. America. Estonia.

PROBOSCINA Audouin 1826

(**P. boryi*). Adhering, of several fused rows of zooecia; sometimes a sheetlike expansion; zooecia tubular; peristomes flush with surface or slightly raised. **Ord., Mesozoic–Recent.**

P. frondosa (Nicholson) (**95**—14). Branches reuniting, with distant zooecial apertures slightly elevated. **U. Ord.** (Maysville, Richmond): Ohio, Ind., Ky., Tenn.; Man.

P. admota Canu and Bassler (**95**—15). Zoarium multiserial, with peristomes very close together. **Paleoc.** (Midway): Ga., Ala.

P. clavatula Canu and Bassler (**95**—13). Zoarium multiserial, its maximum width 0.68 mm; diameter of peristomes 0.12 mm; branches somewhat club-shaped. **U. Eoc.** (Jackson): N. C. to Fla., Ala.

BERENICEA Lamouroux 1821

(**B. prominens*). Thin, unilamellar incrustations without ovicells and with tubular zooecia in irregular lines. **Ord., Sil.; Mesozoic–Recent.**

B. minnesotensis Ulrich (**95**—16, 17). Zooecia similar to *Proboscina*; arranged in irregular rows on flabellate surface. **M. Ord.** (Black River–Decorah): Minn.

DIASTOPORINA Ulrich 1890

(**D. flabellata*). Bifoliate zoaria with tubular zooecia prostrate and partly sunken into connecting mass. **Ord.**

***D. flabellata** Ulrich (**95**—12). Flabellate or fan-shaped expansion; minute, with distant, tubular cells projecting obliquely. **Trenton:** Minn.

HEDERELLA Hall 1883

(**Alecto canadensis* Nicholson). Adhering zoaria with zooecia given off on alternate sides from central tubular axis; apertures terminal. **Sil.–Miss.**

H. filiformis (Billings) (**95**—11). Axial tube and lateral cells sinuous; diameter a little more than 0.5 mm and length of cell tubes usually 1 to 1.25 mm; distinguished from **H. canadensis* by greater diameter and lesser length of cell tubes. **M. Dev.:** N. Y. to Wis.

HERNODIA Hall 1883

(**H. humifusa*). Similar to *Hederella*, but with later zooecia budding alternately from about middle of sides of preceding, and without a central tubular axis. **Dev.**

***H. humifusa** Hall (**95**—25). Cells 5 mm long, gradually enlarging to aperture, which is about 1 mm in diameter, budding about one-third the distance below aperture. **Onondaga:** Falls of the Ohio. **Hamilton:** N. Y., Wis.

REPTARIA Rolle 1851

(**R. stolonifera*). Like *Hederella*, but with zooecial tubes parallel and closely placed, and arising alternately from basal portions of preceding ones. **Dev.**

***R. stolonifera** Rolle (**95**—20, 21). Tubes of unequal length, slightly annulated, with last cell terminal. **Hamilton:** N. Y., Wis.

CRISISINA Orbigny 1850

(**C. cenomana*). Erect branches, smooth dorsal and celluliferous frontal bearing an irregular ovicell on the median crest. **Cret.–Recent.**

C. (Idmonea) triforata Canu and Bassler (**95**—23, 24). Zoarium linear and bifurcated, with fascicles salient and of long convex tubes. **Olig.** (Vicksburg): Ala., Miss.

FILIFASCIGERA Orbigny 1853

(**Tubulipora megaera* Lonsdale). Irregularly branching, repent narrow zoaria, with apertures in salient clusters of two to five or more. **Cret.–Recent.**

***F. megaera** (Lonsdale) (**95**—27, 28). Minute, incrusting, with attached portion flattened, clusters of tubes rising perpendicularly from attached part. **M. Eoc.** (Rancocas): N. J., Del.

DIAPEROECIA Canu 1918

(**Pustulopora intricaria* Busk). Incrusting to ramose zoaria with tubes projecting on the ovicell but without adventitious tubules. **Cret.–Recent.**

D. varians (Ulrich) (**95**—26). Apertures more or less radially arranged about small, depressed, smooth maculae; peristomes ringlike; interspaces solid. **M. Eoc.:** N. J. (Rancocas), Md. (Aquia).

PARTRETOCYCLOECIA Canu 1919

(**Cavaria dumosa* Ulrich). Hollow, ramose with flat orbicular ovicell traversed by tubes. **Eoc.–Olig.**

***P. dumosa** (Ulrich) (**95**—18, 19). Bushy mass of frequently dividing and coalescing branches 1.5 to 3.0 mm thick; surface with maculae slightly depressed, smooth or with mesopores; gonocysts large, rounded or irregular inflations; axial hollow 0.2 to 0.4 mm, with partitions incomplete. **M. Eoc.:** Md (Aquia).

ENTALOPHORA Lamouroux 1821

(**E. cellarioides*). Zoarium usually of ramose cylindrical branches with symmetrical ovicell paralleling the tubes, which open on all sides. **Jura.–Recent.**

E. proboscidea Edwards (**95**—22). Narrow cylindrical branches with apertures of tubes 0.16 mm in diameter and 1.2 to 1.4 mm apart. **Jackson** and **Vicksburg:** N. C. to Fla.

SPIROPORA Lamouroux 1821

(**S. elegans*). Like *Entalophora*, but with apertures in uniserial spirals. **Jura.–Recent.**

S. majuscula Canu and Bassler (**96**—1). Zoarium of very large cylindrical and dichotomous branches, with tubes flat and separated by a salient thread. **M. Jackson:** S. C.

LICHENOPORA Defrance 1823

(**L. turbinata*). Simple orbicular zoarium with ovicell in center, from which zooecia radiate in rows. **Cret.–Recent.**

L. grignonensis Edwards (**95**—29). Free, simple, discoidal zoarium with thick basal striated lamella and tubes small, arranged in quincunx and separated by small irregular cancellae (mesopores). **Eoc.** (Jackson): N. C. to Fla.

LEIOSOECIA Canu and Bassler 1920

(**Multicrescis parvicella* Gabb and Horn). Ramose zoaria with a smooth ovicell obstructing the tube; mesopores present. **Eoc.**

***L. parvicella** (Gabb and Horn) (**96**—9). Branches round, irregular, often anastomosing, of several layers of cellules; apertures subregularly disposed with numerous round mesopores and peristomes. **M. Eoc.:** Md. (Rancocas).

TRETOCYCLOECIA Canu 1919

(**Heteropora dichotoma* Reuss). Solid, ramose, with mesopores and tubes perforating a flat orbicular ovicell. **Cret.–Recent.**

T. tortilis (Lonsdale) (**96**—2, 3). Apertures placed irregularly; with large irregular and angular mesopores. **Mioc.:** Va., S. C.

MITOCLEMA Ulrich 1882

(**M. cinctosum*). Minute, cylindrical, branching stems with zooecia bending abruptly outward and often projecting free. **Ord., Sil.**

M.? mundulum Ulrich (**96**—11). Branches about 0.5 mm in diameter, faintly striated transversely, and with tubular zooecia projecting upward and outward in a spiral series. **M. Ord.** (Trenton): Minn. Estonia.

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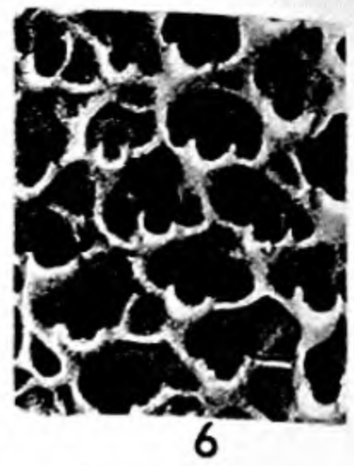
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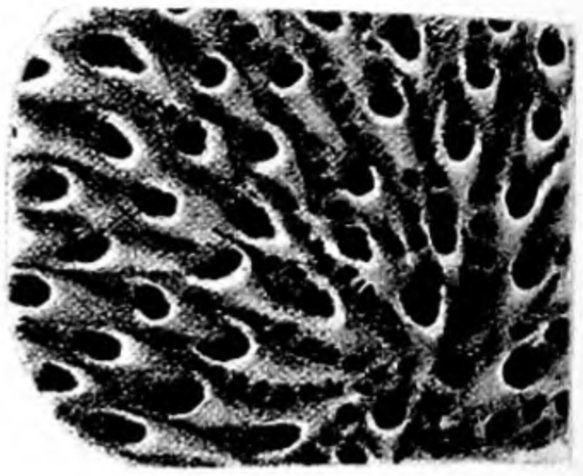
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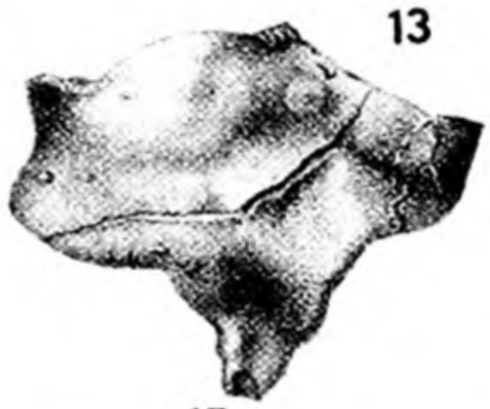
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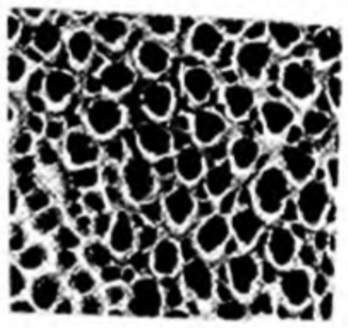
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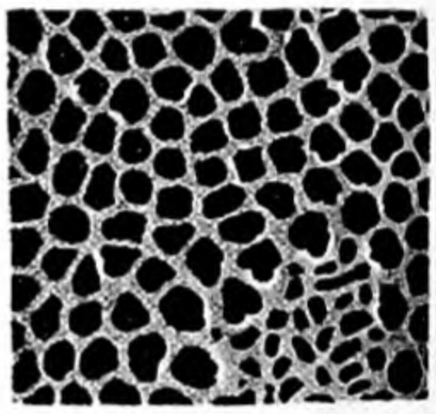
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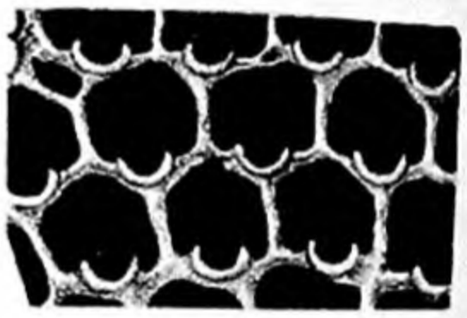
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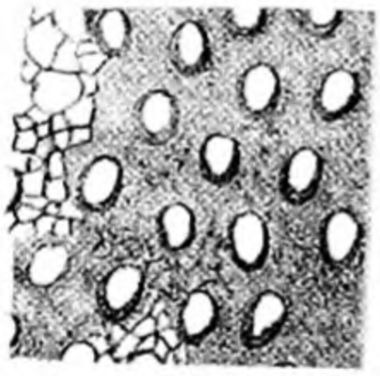
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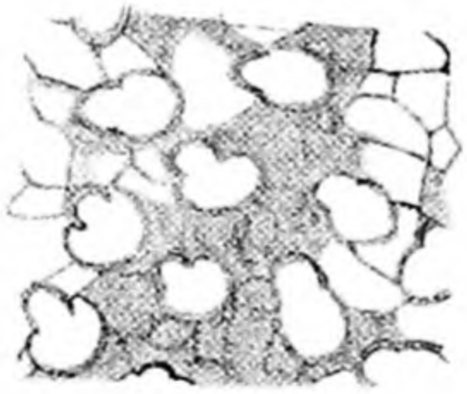
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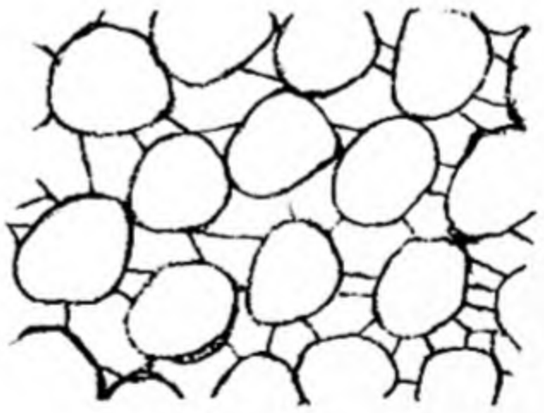
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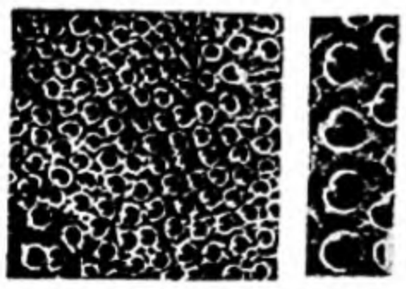
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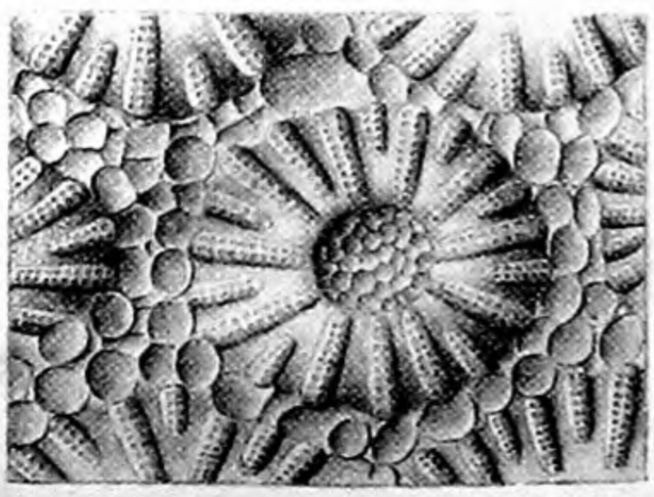
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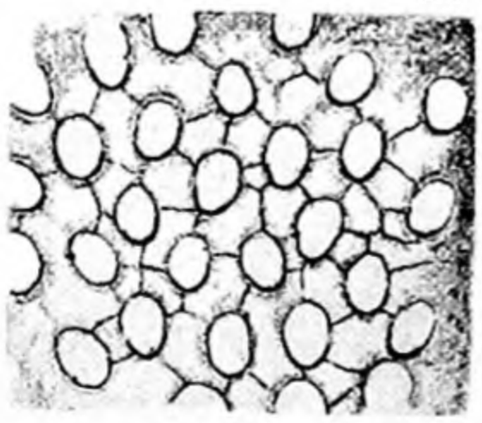
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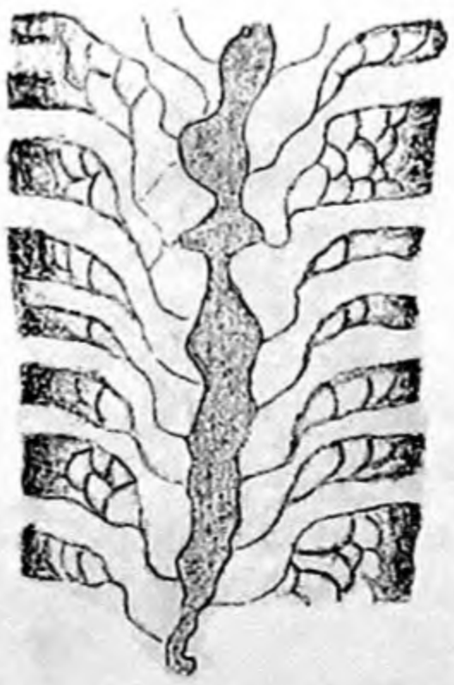
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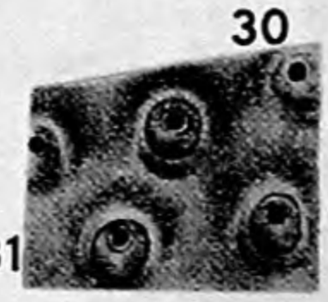
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PHACELOPORA Ulrich 1889

(**P. pertenuis*). Zoarium articulated; two or more zooecia form conical bundles, with circular slightly contracted subterminal apertures. **Ord., Sil.**

***P. pertenuis** Ulrich (**96**—4). Minute, threadlike; segments in linear series, frequently double, producing a dichotomous branching, and each comprising a pair of zooecia, 0.6 to 0.8 mm in length. **U. Ord.:** Anticosti (English Head); **L. Sil.:** Ill. (Girardeau).

CERAMOPORA Hall 1852

(**C. imbricata*). Discoidal zoaria free or attached by center of base; under surface with one or more layers of small, irregular cells; zooecia radiating from depressed center on upper surface, with oblique apertures imbricating; short, irregular mesopores decreasing in number outward; indefinite wall structure with mural openings. **Ord., Sil.**

***C. imbricata** Hall (**96**—12–14). Depressed, hemispherical, flattened or convex on lower side; apertures arched or triangular, opening on all sides toward margin, in alternate imbricating series. **Niagaran:** Ont.; N. Y. (Rochester), Ind. (Osgood).

CERAMOPORELLA Ulrich 1882

(**C. distincta*). Zoarium of incrusting layers, often on other bryozoans, with short, tubular, thin-walled zooecia with oval oblique apertures, the lunarium forming a hood; mesopores abundant. **Ord., Sil.**

C. inclusa Ulrich (**96**—5, 6). Thin incrustations with the oval zooecial apertures, each with three mesopores, occupying bottoms of subtriangular or rhomboidal obliquely depressed spaces; lunarium strongly elevated. **M. Ord.:** Minn. (Black River and Trenton).

***C. distincta** Ulrich (**96**—7). Apertures oblique, with overhanging hood, radially arranged about small maculae and separated by a linear series of mesopores. **U. Ord.:** Cincinnati region (Eden and Maysville).

CREPIPORA Ulrich 1882

(**C. simulans*). Incrusting to massive or hollow branches with long tubular, thin-walled zooecia bearing diaphragms and having angular or subpyriform apertures; lunarium not overarching, its ends usually projecting; mesopores on elevated or depressed maculae only. **Ord., Sil.**

***C. simulans** Ulrich (**96**—17). Clusters of mesopores at intervals of 3 to 4 mm, with zooecial apertures surrounding concentrically and larger near clusters; lunaria not prominent. **M.** and **U. Ord.:** Trenton of Ky. and Tenn.; Maysville of Ohio, Ind., Ky., Tenn., Wis., Ill.

COELOCLEMA Ulrich 1882

(**Diamesopora vaupeli* Ulrich = *Ceramopora alternata* James). Hollow branches lined internally with striated epitheca; zooecia as in *Ceramoporella*, but with thicker walls. **Ord., Sil.**

C. trentonense (Ulrich) (**96**—8). Small apertures in depressed areas with lunarium not prominent, and two to three mesopores to each zooecium, regularly or irregularly arranged. **M. Ord.** (Trenton): Ont.; N. Y., Minn.

ANOLOTICHIA Ulrich 1890

(**A. ponderosa*). Ramose or digitate zoaria of subpolygonal tubes with remote diaphragms, lunarium elevated at surface, traversed by fine vertical tabulated tubes; mesopores few. **Ord., Sil.**

A. impolita (Ulrich) (**96**—18). Large, bushy zoarium of frequently and irregularly divided solid branches; large, moderately thin-walled zooecia, with hexagonal, subrhomboidal apertures, practically of uniform size and with well developed lunaria. **M. Ord.** (Black River–Decorah): Minn., Ia. Estonia.

CERAMOPHYLLA Ulrich 1893

(**C. frondosa*). Like *Ceramoporella*, but erect and bifoliate, the two layers grown back to back. **Ord.**

***C. frondosa** Ulrich (**96**—15, 16). Fronds 0.5 to 2.0 mm thick; substellate maculae of mesopores at intervals of about 3 mm; oblique apertures with posterior margin well elevated, and two to three mesopores to each zooecium. **Black River–Decorah:** Minn.

FAVOSITELLA Etheridge and Foord 1884
(= BYTHOTRYPA Ulrich 1893)

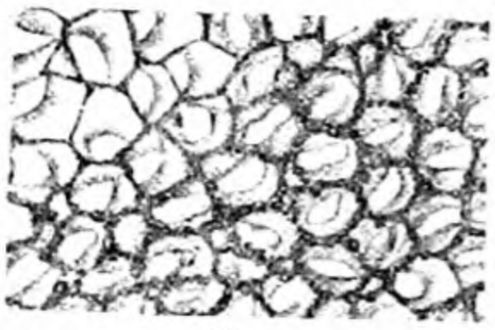
(**Favosites interpuncta* Quenstedt). Massive or lamellate, of long zooecial tubes with thin diaphragms, subovate apertures and large lunaria; numerous mesopores opening to surface and forming internally a loose vesicular structure. **Ord., Sil.**

F. laxata (Ulrich) (**96**—10). Massive, originally

PLATE 96

[Figures are x1, and after Ulrich [CSNH, J 7; Ill G S 8; Minn G S 3 (1)] or Canu and Bassler [USNM, B 106, 125] unless otherwise indicated.]

1. Spiropora majuscula (x12). **2, 3. Tretocycloecia tortilis** (x1, x12). **4. Phacelopora pertenuis** (x12). **5–7. Ceramoporella** spp. **5, 6. C. inclusa** (x40, x18). **7. C. distincta** (x18). **8. Coeloclema trentonense.** Two zoaria (x1) and portion of one enlarged (x9). **9. Leiosoecia parvicella** (x12). **10. Favositella laxata** (x18). **11. Mitoclema mundulum** (x1, x9). **12–14. Ceramopora imbricata** [Pal N Y 6]. Complete zoarium, and enlarged views showing imbricating zooecia. **15, 16. Ceramophylla frondosa.** Fragmental zoarium; portion of surface enlarged (x9). **17. Crepipora simulans** (x12). **18. Anolotichia impolita** (x18). **19, 20. Chilotrypa hispida** (x18). Vertical and tangential sections. **21–23. Fistulipora** spp. **21. F. neglecta** (x18). Tangential section. **22, 23. F. carbonaria** (x18). Tangential and vertical sections. **24. Buskopora dentata.** Surface (x4.5, x9). **25, 26. Botryllopora socialis** (x6) [Pal N Y 6]. Surface, and vertical section. **27–29. Chilotrypa ostiolata** [USGS, B 292]. Tangential and longitudinal sections (x20), and a fragmental zoarium (x2). **30–32. Meekopora clausa.** Fragmental zoarium and cross section; tangential and vertical sections (x18).



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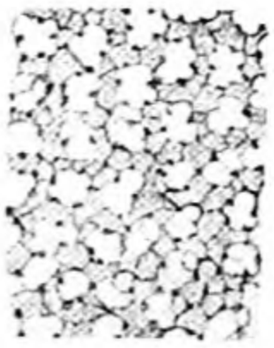

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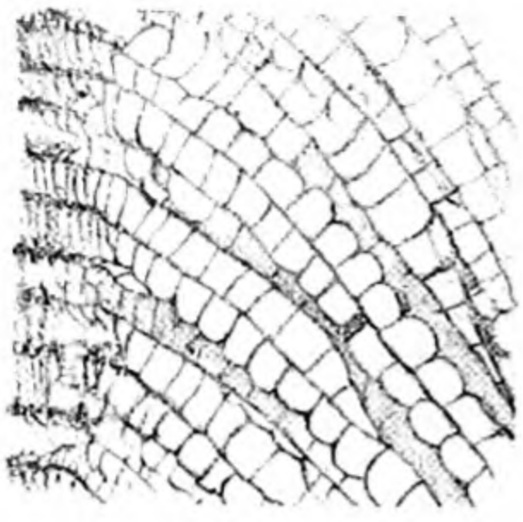

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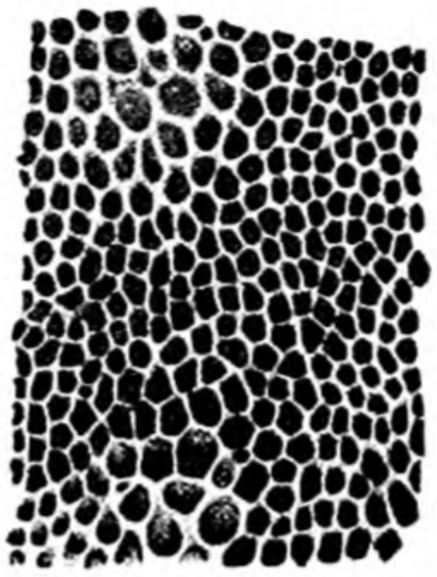

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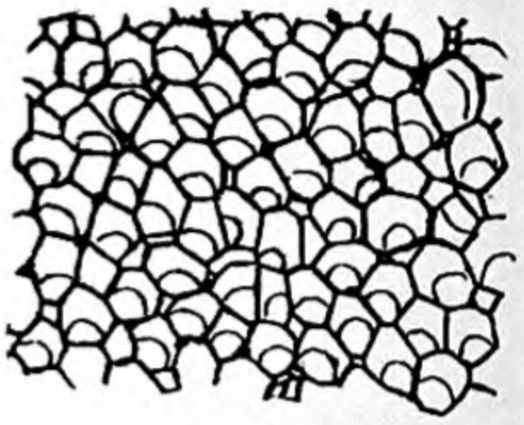

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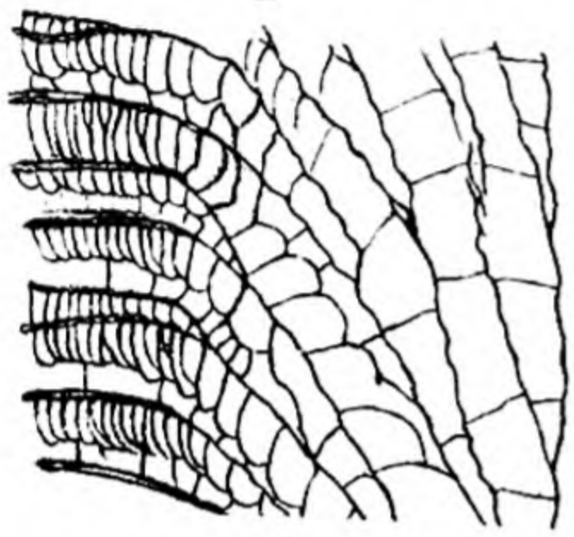

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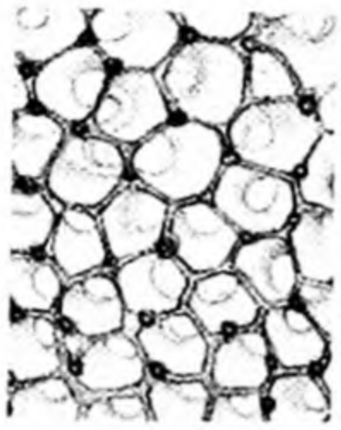

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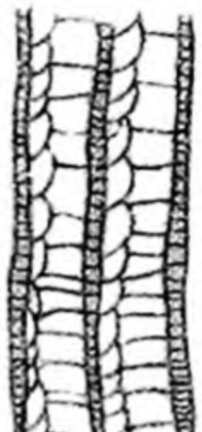

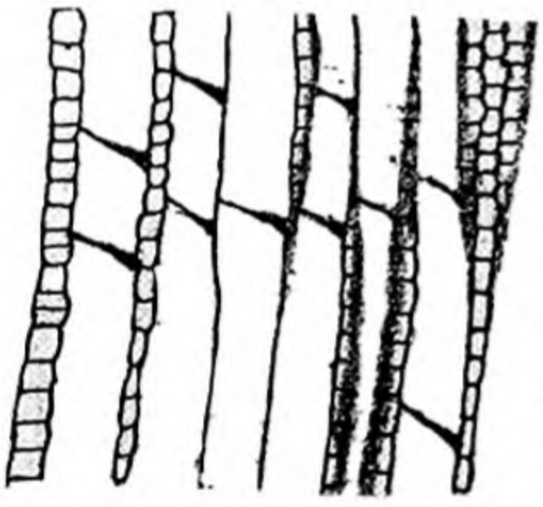

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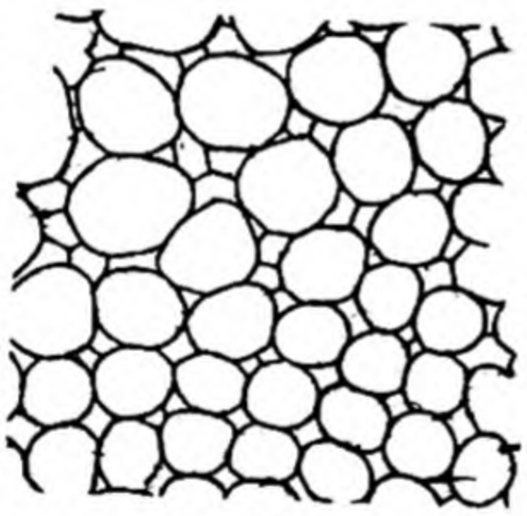

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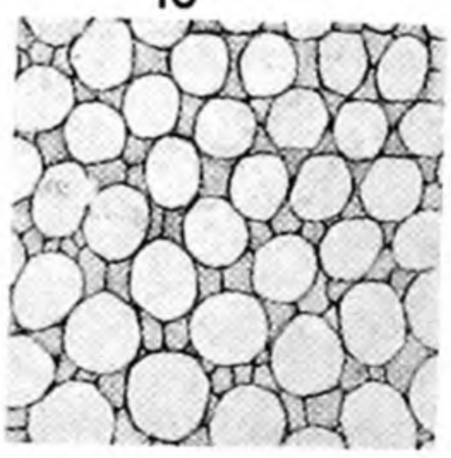

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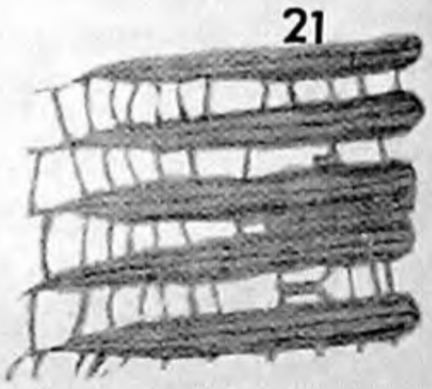

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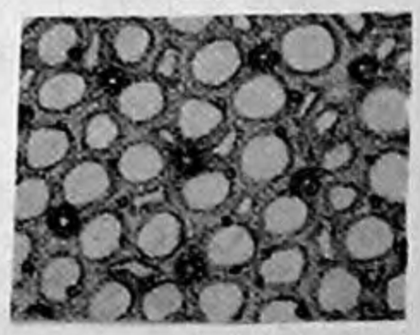

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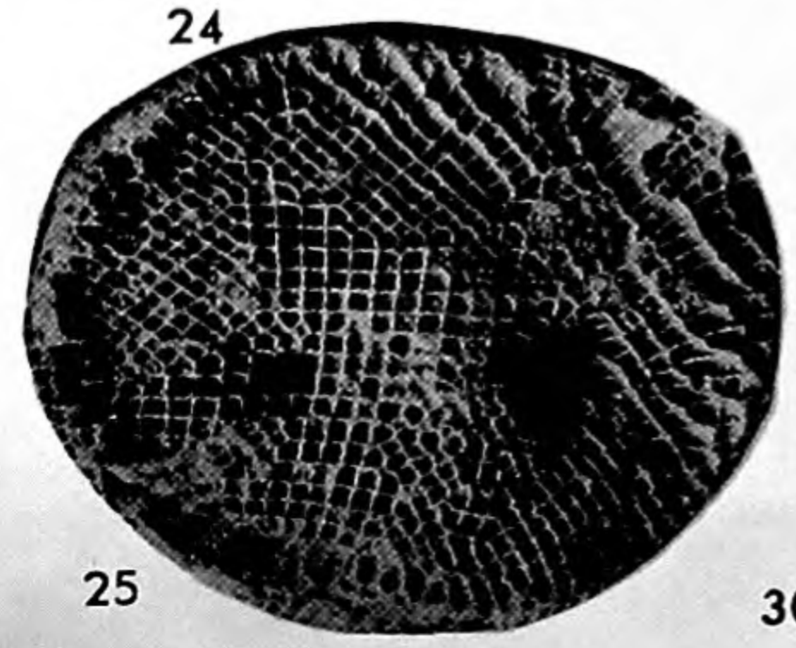

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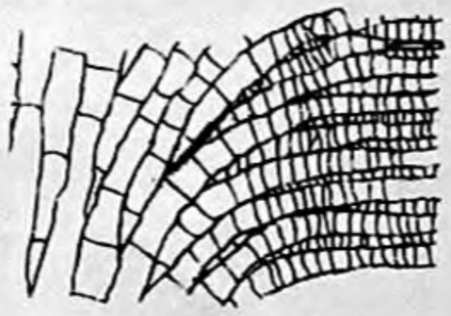

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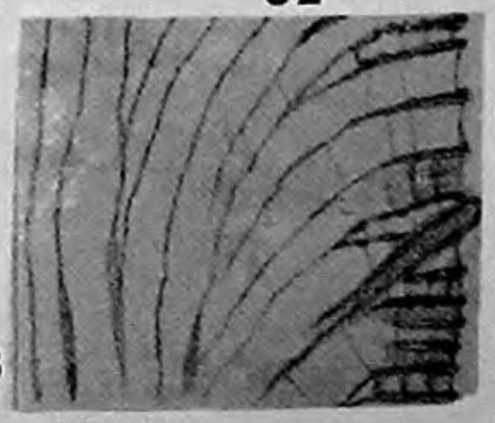

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attached, with basal epitheca; subovate apertures with broad, sharply elevated lunaria; numerous mesopores which at intervals form clusters (in weathered specimens) from which zooecia radiate; interior regularly and loosely arranged with walls of granular structure. **M. Ord.** (Black River, Trenton): Ill., Minn., Ia.

FISTULIPORA McCoy 1850

(**F. minor*). Form varied, under surface with wrinkled epitheca; cylindrical or somewhat compressed zooecial tubes with few diaphragms surrounded by vesicles; apertures subradially arranged about the maculae, with more or less strongly developed lunaria, and separated by smooth or granular interspaces. **Ord.–Perm.**

F. neglecta Rominger (**96**—21). Irregular expansion; base with concentrically wrinkled epitheca; surface with irregularly scattered, smooth maculae from which the circular to oval, oblique apertures radiate irregularly; generally adheres by celluliferous face; commonly identified as *Lichenalia concentrica*. **M. Sil.** (Waldron): Ind., Ky., Tenn.

F. carbonaria Ulrich (**96**—22, 23). Irregularly lamellate or somewhat massive, with diameter of 30 to 100 mm and thickness of 15 mm; apertures oval or circular, with thin, inconspicuous peristomes; a single row of polygonal mesopores which at intervals form substellate maculae. **Penn.:** Ind. (West Franklin), Mo., Kan.

CHILOTRYPA Ulrich 1884

(**C. hispida*). Like *Fistulipora*, with small ramose zoarium; narrow, irregularly contracting and expanding axial tube. **Sil.–Miss.**

C. ostiolata (Hall) (**96**—27–29). Irregularly branching cylindrical stems, gradually tapering toward extremities which are obtuse; apertures about their extremity apart, arranged in spirally ascending lines or irregularly; peristomes strong; interapertural spaces smooth; stems solid or incrusting crinoids. **M. Sil.:** Ont.; N. Y. (Rochester), Ind. (Osgood).

***C. hispida** Ulrich (**96**—19, 20). Zooecia in regular obliquely intersecting series, eight to nine in 25 mm; small maculae, surrounded by somewhat larger cells; lip decreasing from posterior end forward; interspaces dense above, vesicular lower down. **U. Miss.** (Glen Dean): Ill., Ky.

BUSKOPORA Ulrich 1886

(**B. dentata*). Like *Fistulipora*, but with pronounced lunaria projecting as a bidenticulate process nearly halfway across aperture. **Dev.**

***B. dentata** Ulrich (**96**—24). Incrusting or free expansions, with concentrically wrinkled epitheca on lower side; apertures in regular diagonally intersecting lines; slightly elevated maculae with smooth centers, at intervals of 5 mm. **Onondaga:** Falls of Ohio.

MEEKOPORA Ulrich 1889

(**M. eximia*). Bifoliate (two layers growing back to back), with zooecia curving gently outward. **Sil.–Penn.**

M. clausa (Ulrich) (**96**—30–32). Compressed branches, surface with substellate maculae between which the zooecia are uniformly distributed in very regular oblique series; interapertural space flat or slightly concave, usually smooth or minutely pitted or granular, vesiculose in lower part. **U. Miss.** (Chester): Ill., Ky.

BOTRYLLOPORA Nicholson 1874

(**B. socialis*). Discoidal, often coalescing, attached bodies, with apertures in two rows on elevated radiating ridges which increase by bifurcation or implantation; lunaria absent. **Dev.**

***B. socialis** Nicholson (**96**—25, 26). Alternate ridges extend to central area, others one-half to two-thirds that distance; apertures minute, often in contact or inosculating. **Onondaga:** Falls of the Ohio; **Hamilton:** Ont.; N. Y., Mich.

Order Trepostomata. Zoaria calcareous, compound, composed of long zooecial tubes with straight or curved partitions; zooecial walls thickened in mature region, where there are numerous diaphragms and cystiphragms; surface bearing monticules or maculae, or larger or smaller cells distributed at regular intervals; zooecial tubes separating upon fracture of zoarium. **Ord.–Penn.**

MONTICULIPORELLA Bassler 1934

(= MONTICULIPORA Orbigny 1849)

(**Monticulipora mammulata* Orbigny). Walls granulose; cystiphragms throughout both regions. **Ord., Sil.**

M. arborea (Ulrich) (**97**—1, 2). Subcylindrical branches; monticules low or absent; apertures with

PLATE 97

[Figures are x18 and after Ulrich [CSNH, J 5, 6; Ill G S 8; Minn G S 3 (1)] unless otherwise indicated.]

1, 2. Monticuliporella arborea. Tangential and vertical sections. **3–5. Atactoporella typicalis.** A fragmental zoarium (x1); vertical and tangential sections. **6–8. Homotrypa minnesotensis.** A fragmental zoarium (x1); surface (x9); vertical section. **9–13. Homotrypa spp. 9, 10. H. flabellaris.** Vertical and tangential sections. **11–13. H. subramosa.** A fragmental zoarium (x1); vertical and tangential sections. **14, 15. Mesotrypa quebecensis.** Vertical and tangential sections. **16, 17. Aspidopora elegantula.** Complete zoarium (x1), and tangential section. **18, 19. Prasopora simulatrix.** Vertical and tangential sections. **20–23. Amplexopora cingulata.** Surface, and tangential section; greatly magnified tangential section (x40); vertical section. **24, 25. Rhombotrypa quadrata** (x6) [photographs furnished by R. S. Bassler]. **26, 27. Petalotrypa compressa.** Tangential and vertical sections. **28–33. Dekayella spp. 28, 29. D. praenuntia echinata.** Zoarium (x1) and surface (x9). **30. D. praenuntia multipora.** Vertical section. **31. D. praenuntia simplex** (x50). Vertical section. **32, 33. D. obscura.** Tangential and vertical sections.

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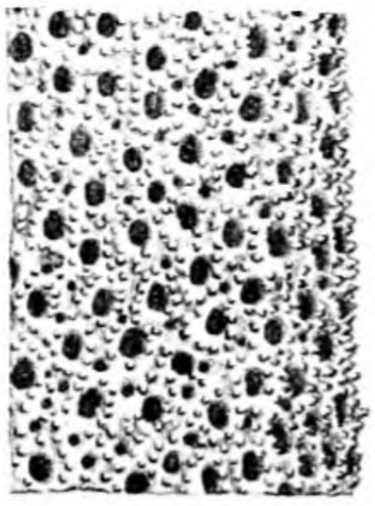
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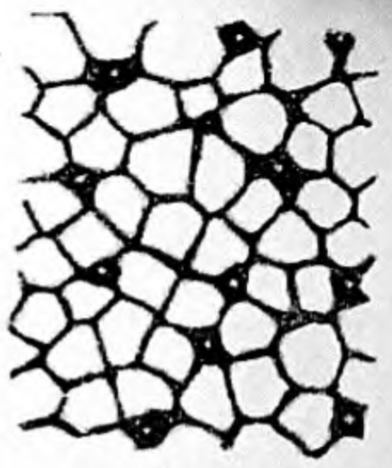
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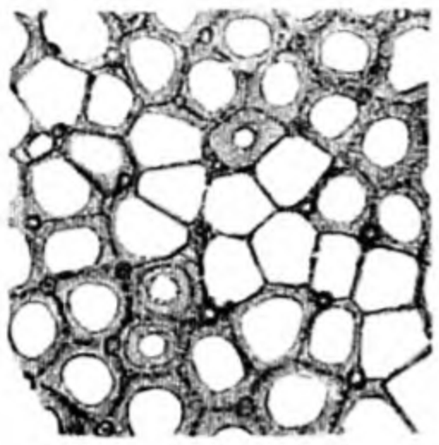
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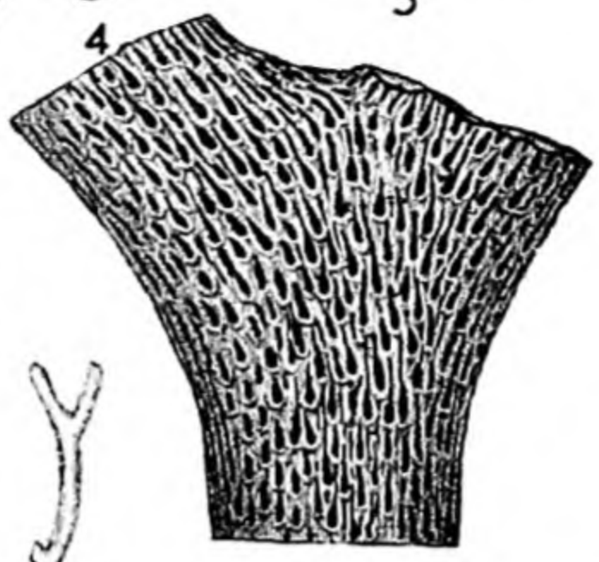
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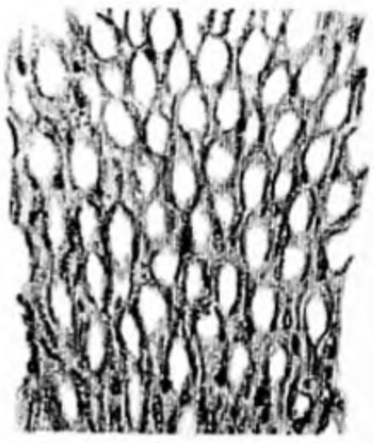
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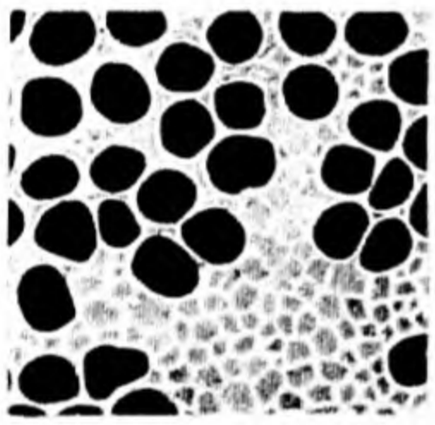
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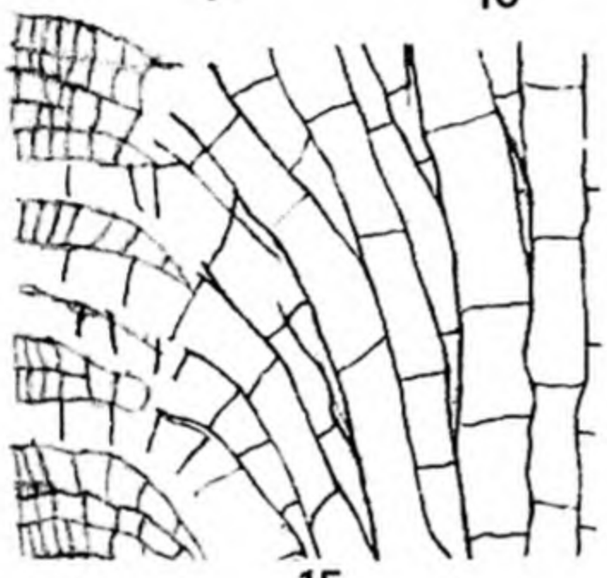
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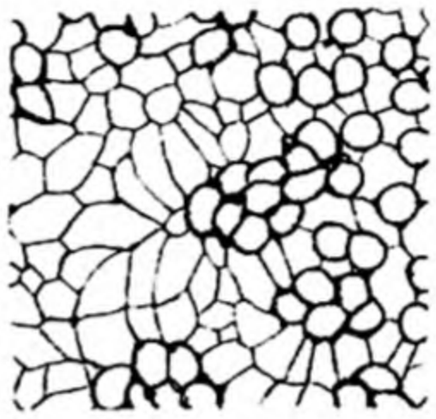
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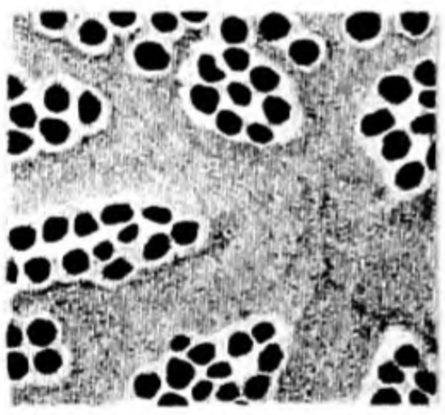
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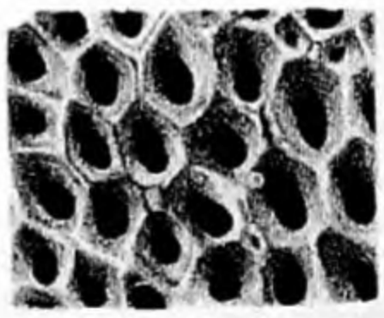
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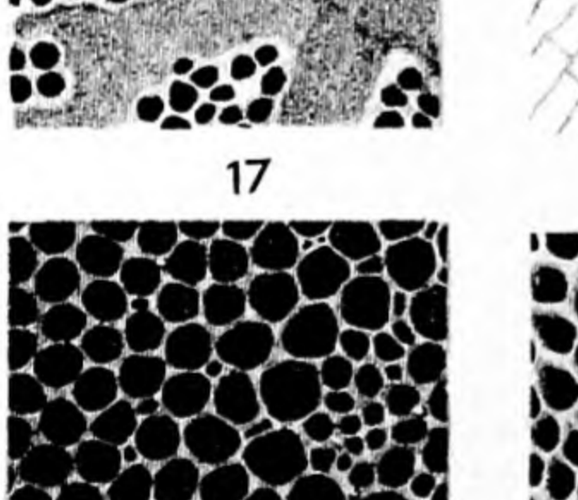
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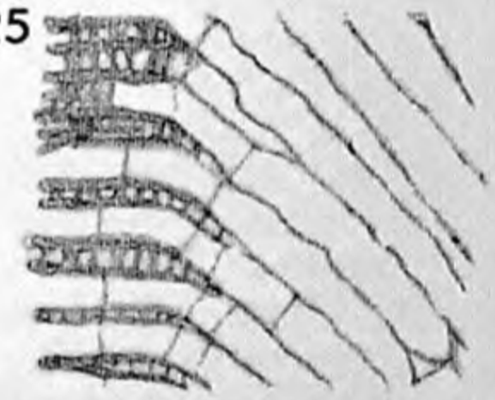
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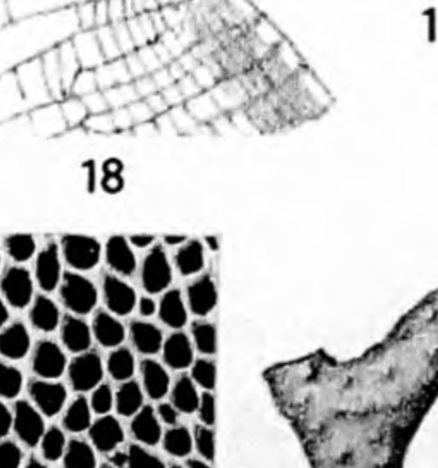
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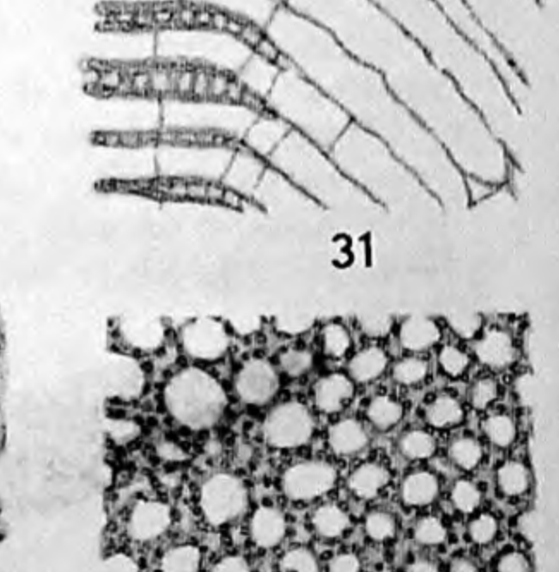
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minutely granular walls bearing acanthopores; mesopores absent. **M. Ord.** (Trenton): Ky., Minn., Ia.

***M. mammulata** (Orbigny). Irregularly lobate or palmate, with prominent conical or sometimes elongated monticules; cells of monticules of about same size as others. **U. Ord.** (Maysville): Ohio, Ky.

ATACTOPORELLA Ulrich 1883

(**A. typicalis*). Generally incrusting; apertures petaloid; mesopores numerous, frequently isolating the zooecia; acanthopores very numerous. **Ord., Sil.**

***A. typicalis** Ulrich (**97**—3–5). Thin crusts on other bryozoans; groups of larger zooecia at unequal intervals, sometimes on monticules; zooecia very regular. **U. Ord.** (Eden): Ohio, Ky.

HOMOTRYPA Ulrich 1882

(**H. curvata*). Frondescent or ramose; surface showing monticules or maculae of larger zooecia; zooecia with very thin or finely crenulated walls, remote diaphragms in immature and cystiphragms in mature region, and apertures often oblique; mesopores and acanthopores present, the former few and in clusters. **Ord., Sil.**

H. subramosa Ulrich (**97**—11–13). Irregularly branching; monticules low and poorly defined; axial region tabulated. **M. Ord.** (Black River, Trenton): Minn., Ia.; Estonia.

H. minnesotensis Ulrich (**97**—6–8). Subcylindrical branches 5 to 15 mm in diameter, generally dividing dichotomously; clusters of larger zooecia conspicuous in one variety, raised on monticles, about 25 mm between centers; true mesopores absent; acanthopores exceedingly small and few; apertures oblique. **M. Ord.** (Black River–Decorah): Ky., Tenn., Minn., Ia.

H. flabellaris Ulrich (**97**—9, 10). Growth fan-shaped; surface with obscure maculae having centers about 4 mm apart; zooecial walls very thin, appearing flexuous or crenulated in section; diaphragms numerous in mesopores, few and remote in zooecia. **U. Ord.** (Maysville, Richmond): Ohio, Ind., Ky., Tenn., Ill.

PRASOPORA Nicholson and Etheridge 1877

(**P. grayae*). Massive zoaria, usually free, with wrinkled epitheca on under side; zooecia prismatic or cylindrical, thin-walled, with cystiphragms, and generally surrounded by prismatic mesopores with crowded diaphragms; acanthopores rarely numerous or strong. **Ord.**

P. simulatrix Ulrich (**97**—18, 19). Discoidal to hemispherical or subconical zoaria with concave base; clusters of larger zooecia with more numerous mesopores at intervals of about 4 mm, sometimes on monticules; an average of 11 zooecia in 3 mm. **Trenton:** Ont.; Va., Ky., Tenn., Wis., Minn.

ASPIDOPORA Ulrich 1882

(*A. areolata*). Zoarium expanded or of superimposed layers, with basal epitheca; zooecia decreasing in size outward from center, without diaphragms and few cystiphragms; mesopores numerous, with close diaphragms; acanthopores small or absent; differs from *Prasopora* mainly in small size and thinness of expansion. **Ord., Sil.**

A. elegantula (Ulrich) (**97**—16, 17). Surface with large clusters of large zooecia at intervals of 3 to 4 mm, generally elevated; mesopores between all zooecia; cystiphragms almost or quite wanting. **M. Ord.** (Trenton): Minn.

MESOTRYPA Ulrich 1893

(**Diplotrypa infida*). Like *Prasopora*, but flatter and with oblique or funnel-shaped diaphragms, and with zooecia separated by prismatic mesopores having numerous diaphragms; acanthopores sometimes large. **Ord., Sil.**

M. quebecensis (Ami) (**97**—14, 15). Height of zoarium 4 to 20 mm, diameter 12 to 45 mm; oblique diaphragms in zones; acanthopores absent. **M. Ord.** (Trenton): Que.; Vt., N. Y., Ky., Ia.

ATACTOTOECHUS Duncan 1939

(**A. typicus*). Ramose or massive, integrate or amalgamate; walls intermittently thickened, thickened zones laminated, thin zones granular; diaphragms and cystiphragms more numerous opposite thick-walled parts of zooecia: intermittent thickening a regular feature of zoarial growth, hence crowded bands of diaphragms and cystiphragms developed at intervals; mesopores absent, but small zooecia occasionally present; acanthopores laminated, few or absent, usually restricted to monticules or groups of larger zooecia. Like *Amplexopora* in growth, wall structure and absence of mesopores, but differs in the presence

PLATE 98

[Figures are x18 and after Ulrich [CSNH, J 6; Ill G S 8; or Minn G S 3 (1)] unless otherwise indicated.]

1–3. Batostomella spinulosa. Vertical section; fragmental zoarium (x1); surface showing sunken interspaces, mesopores, and abundant acanthopores. **4–6. Batostomella granulifera** [USGS, B 292]. Fragmental specimen (x2); tangential section (x20), showing solid interzooecial spaces and numerous acanthopores; vertical section (x30). **7. Dekayia aspersa.** Tangential section. **8, 9. Tabulipora carbonaria.** Tangential and vertical sections. **10–13. Bythopora herricki.** Fragmental specimen (x1); surface (x9); tangential and vertical sections. **14–20. Constellaria** spp. **14, 15. C. varia.** Surface, and vertical section. **16–20. C. florida.** Tangential section; enlarged macula; peripheral part of vertical section; typical zoarium, surface and cross section (x1). **21, 22. Eridotrypa mutabilis.** Typical specimen (x1) and surface of an old example. **23, 24. Lioclema gracillimum.** Fragmental zoarium (x9) and portion of surface enlarged. **25–27. Hemiphragma** spp. **25. H. whitfieldi** [USNM, Pr 30]. Type specimen (x1.5). **26, 27. H. imperfectum.** Surface (x12); outer part of vertical section. **28, 29. Eridotrypella obliqua.** Surface (x12); typical specimen (x1). **30–32. Nicholsonella** spp. **30. N. pulchra.** Vertical section. **31, 32. N. vaupeli.** Vertical and tangential sections. **33–35. Hemiphragma** spp. **33, 34. H. tenuimurale.** Vertical and tangential sections. **35. H. whitfieldi** [USNM, Pr 30]. Vertical section (x20) showing incomplete diaphragms.

of cystiphragms and in the intermittent thickening of the walls. **Dev.**

***A. typicus** Duncan. Characterized by strong monticules and longer mature region developed beneath monticules. **Traverse:** Mich. (Norway Point).

A. winchelli (Ulrich). Zoarium lamellate, formed of superimposed layers of thin-walled angular zooecia without acanthopores but with closely set cystiphragms; six to eight zooecia in 2 mm. **Traverse:** Mich.

AMPLEXOPORA Ulrich 1882

(**A. cingulata*). Ramose, discoidal, or massive zoaria with prismatic zooecia having diaphragms; acanthopores variable. **Ord.**

***A. cingulata** Ulrich (**97**—20–23). Ramose, consisting of cylindrical or subcylindrical branches dividing dichotomously; monticules absent; apertures subpolygonal, a moderately thin wall studded with granules between them; groups of zooecia of larger size; mesopores absent. **Maysville:** Ohio, Ky.

RHOMBOTRYPA Ulrich and Bassler 1904

(**Chaetetes quadratus* Rominger). Ramose zoaria with zooecia quadrate in cross-section. **Ord.–Dev.**

***R. quadrata** (Rominger) (**97**—24, 25). Irregularly cylindrical branches, 4.5 to 10.5 mm thick; tubes rhombic in section, arranged in curved diagonal lines; mesopores and monticules absent. **U. Ord.** (Richmond): Ohio, Ind., Wis., Ill., N. Mex.; Man.

PETALOTRYPA Ulrich 1889

(**P. compressa*). Irregular, compressed, bifoliate branches or fronds, with prismatic zooecia arising from strongly flexuous mesotheca; apertures polygonal. **Sil., Dev.**

***P. compressa** Ulrich (**97**—26, 27). Smooth, with scarcely appreciable clusters of slightly larger and somewhat more separated zooecia; zooecia subpolygonal to hexagonal; mesopores irregular, scattered, sometimes in clusters; height 2 mm or more; width 1 cm or less; thickness 1 to 4 mm. **M. Dev.** (Hamilton): Wis., Ill., Ia.

DEKAYELLA Ulrich 1882

(**D. obscura*). Ramose zooecia with numerous diaphragms, large and small acanthopores, and a variable number of mesopores. **Ord.**

D. praenuntia Ulrich (**97**—28–31). Compressed cylindrical, 4 to 12 mm in diameter, without monticules but with inconspicuous clusters of large zooecia; few irregularly disposed mesopores and acanthopores; numerous varieties. **M. Ord.** (Black River, Decorah): Minn., Ia.; Estonia.

***D. obscura** Ulrich (**97**—32–33). Small, slender stems, variously branching; monticules obscure. **Eden:** Cincinnati region.

D. ulrichi (Nicholson). Coarse, subcylindrical branching stems, three or more times diameter of those in *D. obscura*; low monticules of smaller cells (mesopores) regularly disposed and surrounded by cells somewhat larger than the average. **Eden:** Cincinnati region.

DEKAYIA Edwards and Haime 1851

(**D. aspera*). Subcylindrical or flattened stems growing from large base; one set of acanthopores and few or no mesopores and diaphragms; otherwise like *Dekayella*. **Ord.**

***D. aspera** E and H (**98**—7). General form and aspect like *Dekayella ulrichi*, from which it differs in generic characters. **Maysville:** Ohio, Ky., Tenn.

BATOSTOMELLA Ulrich 1882

(**B. spinulosa*). Slender branches, with thick-walled zooecia having few diaphragms and small, circular or oval apertures with rounded or grooved interspaces; numerous small acanthopores and mesopores, the latter with subcircular openings. **Sil.–Perm.**

B. granulifera (Hall) (**98**—4–6). Oval to elongate apertures margined by wavy, raised, granulose lines, double between cells. **Niagaran:** Ont.; N. Y. (Rochester), Ind. (Osgood).

***B. spinulosa** Ulrich (**98**—1–3). Subcircular or oval apertures, surface finely spinose in well preserved specimens from abundance of acanthopores. **U. Miss.** (Chester): Ky., Ill.

BYTHOPORA Miller and Dyer 1878

(**B. fruticosa* Miller and Dyer = *Helopora dendrina* James). Usually slender branches; zooecia practically without diaphragms and with oblique apertures, grooved interspaces, few mesopores, and comparatively strong acanthopores, rarely more than one per zooecium. **Ord.–Dev.**

B. herricki (Nicholson) (**98**—10–13). Apertures long drawn out anteriorly and narrow. **M. Ord.** (Black River): Minn.

ERIDOTRYPA Ulrich 1893

(**E. mutabilis*). Zoaria consisting of slender branches with more or less thick-walled zooecia with diaphragms which may be absent in the axial and apertural regions; mesopores with closely set diaphragms; acanthopores small and scarce or absent. **Ord.–Dev.**

***E. mutabilis** Ulrich (= **E. aedilis** (Eichwald)) (**98**—21, 22). Slender, branching, cylindrical stems averaging 3.5 to 4.5 mm in diameter; apertures very oblique, especially in young specimens; small maculae commonly present in older stems; axial portion of tubes with diaphragms distant about twice their diameter. **M. Ord.** (Black River, Trenton): Ont.; Ohio, Ky., Tenn., Wis., Minn., Ia.

ERIDOTRYPELLA Duncan 1939

(**Eridotrypa obliqua* Ulrich). Like *Eridotrypa* but with the clear cut amalgamate walls with large typical acanthopores like those in the *Heterotrypidae*. **Dev.**

E. obliqua (Ulrich) (**98**—28, 29). Zoarium of

branching tuberculated stems composed of obliquely arranged zooecia with few or no mesopores and angular elongated apertures, of which seven occur in 2 mm. **Traverse:** Mich.

TABULIPORA Young 1883
(= STENOPORA Lonsdale 1844)

(**T. scotica* Lee = **T. urei** Young (part)). Zoarium ranging from ramose to laminar or incrusting, with or without monticules, and with zooecial wall periodically thickened in mature region; diaphragms perforated centrally; few irregularly distributed mesopores and large acanthopores. **Miss.–Perm.**

T. carbonaria (Worthen) (**98**—8, 9). Subcylindrical branches 10 to 15 mm in diameter; surface smooth and without cell clusters; apertures angular to subcircular, frequently thick-walled, with numerous acanthopores and few mesopores. **Penn.:** Ohio, Ill., Kan., N. Mex. (Magdalena).

LIOCLEMA Ulrich 1882

(**Callopora punctata* Hall). Zoarium usually ramose with wall structure of *Stenopora*, but not beaded and with complete diaphragms and tabulated mesopores. **Ord.–Perm.**

L. gracillimum Ulrich (**98**—23, 24). Zoarium of thin branches, 1.5 mm wide, with smooth surface and elliptical apertures surrounded by a large number of very small mesopores; small numerous acanthopores. **M. Miss.** (Keokuk): Ia.

CONSTELLARIA Dana 1846

(**C.* (*Ceriopora*) *constellata*). Erect, flattened branches or fronds from an attached basal expansion; surface with depressed stellate maculae, the spaces between rays elevated and bearing two to three short rows of closely approximated apertures; mesopores aggregated into maculae with crowded diaphragms. **Ord.**

C. varia Ulrich (**98**—14, 15). Flattened branches with large, irregularly stellate maculae very slightly depressed; zooecial apertures in clusters of 4 to 10 each, slightly or not at all elevated; apertures subcircular, **Trenton:** Ont.; Tenn., Minn.

C. florida Ulrich (= **C. constellata** Van Cleve) (**98**—16–20). Flattened branches covered with crowded "stars," the rays of which are sharp, petaloid, and strongly elevated. **Maysville:** Ohio, Ind., Ky., Tenn.

NICHOLSONELLA Ulrich 1889

(**N. ponderosa*). Laminar expansions, sometimes giving off flattened intertwining branches or fronds; interzooecial spaces wide, with numerous mesopores, having thicker and more numerous diaphragms than zooecial tubes, but obliterated with age by filling of secondary calcareous deposit. **Ord., Sil.**

N. pulchra Ulrich (**98**—30). Irregular, flattened branches with faint and often indefinite monticules; interzooecial spaces papillose. **M. Ord.:** Tenn. (Stones River).

N. vaupeli Ulrich (**98**—31, 32). Flattened, inosculating expansions with evenly distributed, low monticules of pores larger than ordinary, with center free from pores. **U. Ord.** (Maysville): Cincinnati region.

BATOSTOMA Ulrich 1882

(**Monticulipora* (*Heterotrypa*) *implicata* Nicholson). Irregular branches from large basal expansion; zooecia thin-walled in immature and thick in mature region, ringlike in section, with diaphragms; mesopores irregular and acanthopores large. **Ord., Sil.**

B. fertile Ulrich (**99**—1, 2). Large zoarium of coarse, compressed branches, with round or polygonal apertures and often few mesopores; clusters of larger zooecia inclosing a stellate macula scattered over the surface. **M. Ord.** (Black River–Decorah): Minn.; Estonia.

HEMIPHRAGMA Ulrich 1893

(**Batostoma irrasum*). Like *Batostoma*, but diaphragms in peripheral part of zooecia are incomplete. **Ord.**

H. tenuimurale Ulrich (**98**—33, 34). Cylindrical or compressed stems with thin-walled polygonal apertures, without acanthopores and with a few mesopores; diaphragms in peripheral region incomplete. **Trenton** (Prosser): Minn., Ia.

H. whitfieldi (James) (**98**—25, 35). Like preceding, but zooecia much larger, and with crinkled walls readily visible on broken surface, **Eden:** Cincinnati region.

H. imperfectum (Ulrich) (**98**—26, 27). Branches robust, 20 mm or more thick, branching at short intervals; surface marked with very slightly elevated aggregations of larger cells surrounding a cluster of mesopores, about 3 mm apart; zooecia subpolygonal, about seven in 2 mm, with subcircular apertures. **Richmond:** Tenn., Ill., Tex., N. Mex.

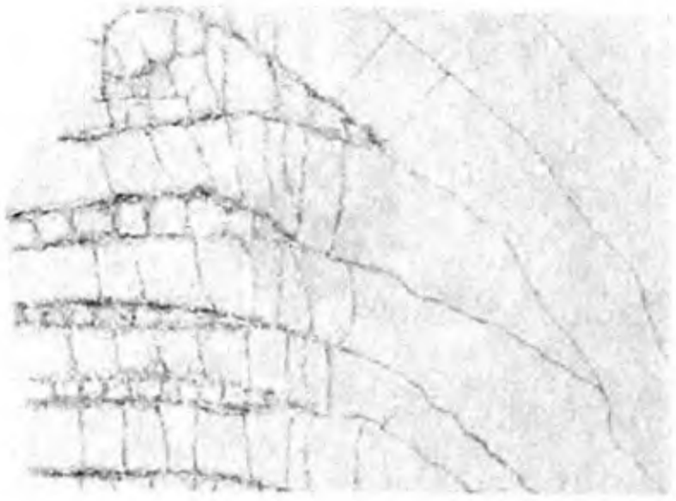
STROMATOTRYPA Ulrich 1893

(**S. ovata*). Incrusting, with short zooecia, which are oval in transverse section and with few diaphragms; wall thin, with periodically constricted tubuli, one or more per zooecium; oval apertures with minutely pimpled peristomes separated by depressed interspaces; closely tabulate mesopores, rarely showing on surface. **Ord.–Dev.**

***S. ovata** Ulrich (**99**—12, 13). Incrusting shells or other bryozoans, rarely free; without monticules, but with smooth areas of more widely separated apertures. **M. Ord.** (Black River–Decorah): Wis., Minn.

MONOTRYPA Nicholson 1879

(**Chaetetes undulatus*). Massive hemispherical or discoidal zoaria; zooecia comparatively large and prismatic, with thin and often crinkled walls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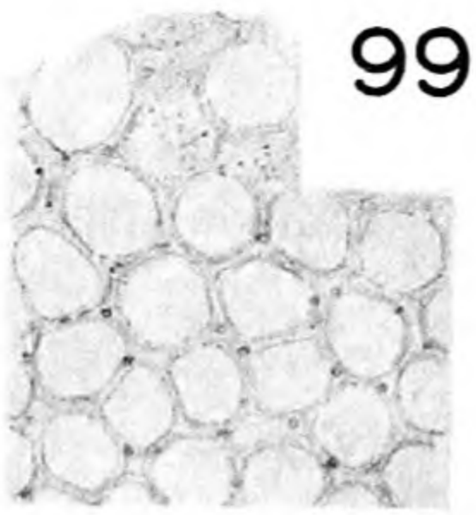
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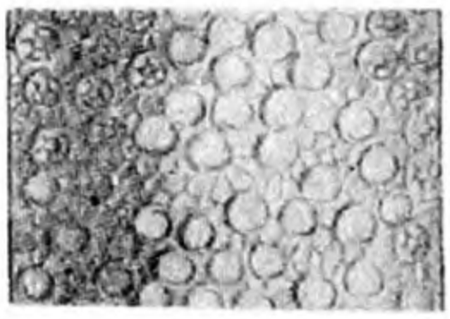
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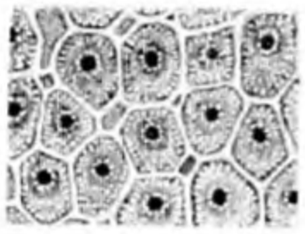
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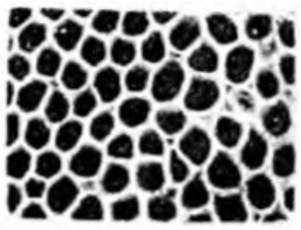
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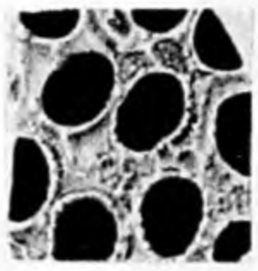
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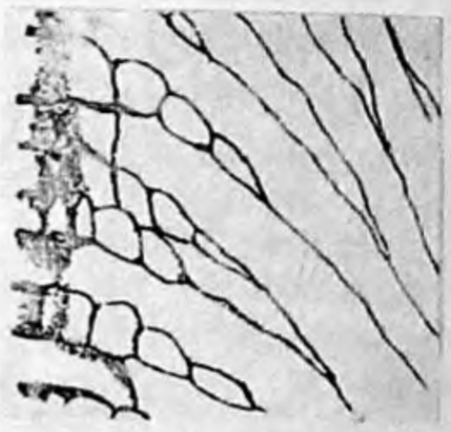
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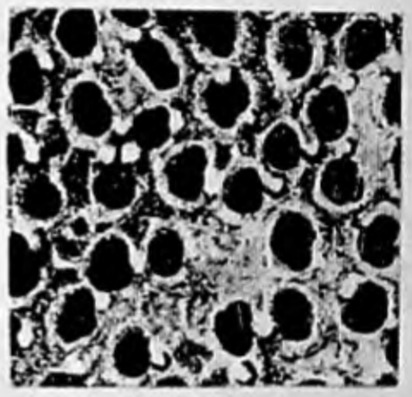
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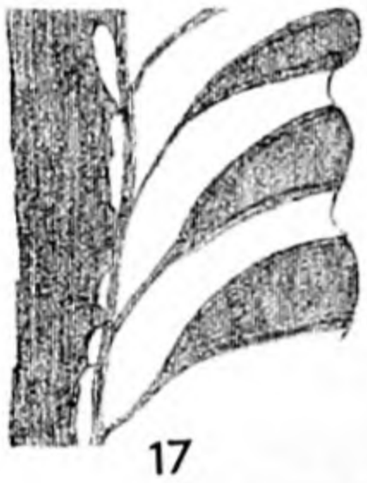
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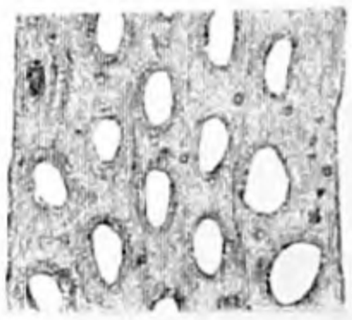
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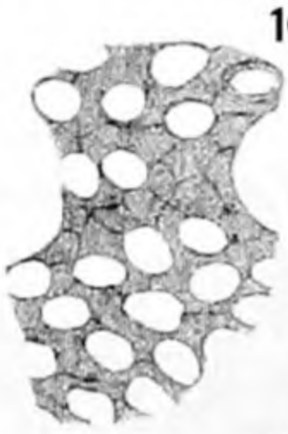
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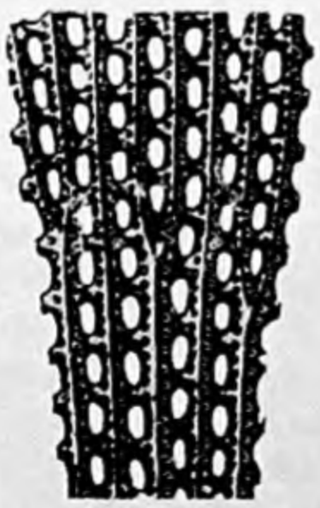
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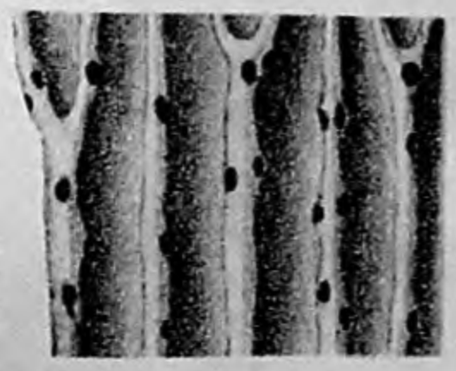
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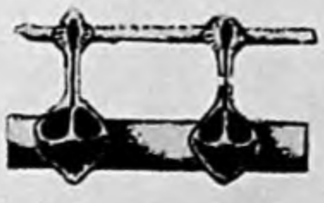
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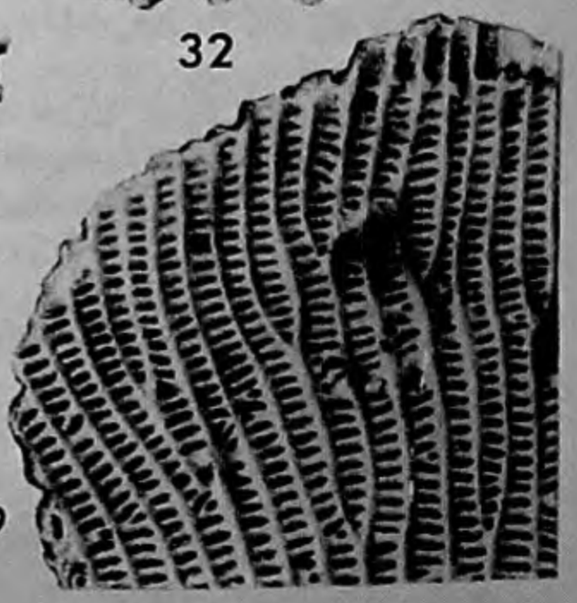
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throughout; diaphragms remote; mesopores and acanthopores absent. **Ord.–Dev.**

M. magna Ulrich (**99**—3, 4). Large expanded masses composed of thin-walled polygonal zooecia, about nine in 5 mm, but without mesopores or acanthopores; vertical sections show strongly undulating thin walls crossed by complete horizontal diaphragms averaging twice the tube diameter apart. **M. Ord.:** Ill. (Platteville).

TREMATOPORA Hall 1851

(**T. tuberculosa*). Zoarium ramose; surface smooth or with monticules; zooecia thin-walled, the contact lines of adjoining zooecial walls distinct; diaphragms few, in proximal end of zooecium; apertures circular or oval with more or less well marked peristome; interspaces solid; mesopores irregularly angular, often obscurely moniliform, with diaphragms at constricted parts; acanthopores of medium or small size usually present. **Ord., Sil.**

***T. tuberculosa** Hall (**99**—14–16) Irregularly ramose and stout branches; tuberculated monticules; tubular cells with oval apertures and thin elevated margin which is spinulose from acanthopores; interapertural spaces solid, but separate below. **M. Sil.:** Ont.; N. Y. (Rochester), Ind. (Osgood).

HALLOPORA Bassler 1911

(**Callopora elegantula* Hall). Branching, and frequently anastomosing into bushy clumps, with prismatic zooecia which later usually become cylindrical, and have their apertures operculated; diaphragms closely set except in central part of tube, and crowded in the angular mesopores. **Ord.–Dev.**

H. multitabulata (Ulrich) (**99**—8–10). With strongly elevated monticules, few mesopores and numerous diaphragms. **M. Ord.** (Black River, Trenton): Ont.; N. Y., Ky., Tenn., Minn., Ia.

H. dalei (Edwards and Haime) (**99**—11). Branches more slender than preceding and with less prominent monticules, which sometimes unite into ridges, as in *H. rugosa*. **U. Ord.** (Maysville): Cincinnati region.

H. rugosa (Edwards and Haime) (**99**—5). Of the type of *H. ramosa*, but with monticules united into prominent transverse ridges with zooecial apertures. **U. Ord.** (Maysville): Cincinnati region.

***H. elegantula** (Hall) (**99**—6, 7). Branches solid, apertures large, circular and operecula with central perforation and radiating ridges. **Niagaran:** Ont.; N. Y., Ind., Ill., Ky., Tenn.

Order Cryptostomata. Zoaria compound, often highly complex, differing from Trepostomata in that the primitive part of the tube is usually much shorter and the passage to the mature region more abrupt, i.e., the zooecia have a short tubular primitive portion, above which the mature part is a tubular shaft or vestibule, often with hemisepta, and surrounded by vesicular or solid calcareous material; external aperture round; probably Paleozoic representatives of the Cheilostomata. **Paleozoic.**

SUBRETEPORA Orbigny 1849

(**Intricaria reticulata* Hall). Irregularly anastomosing branches, two to eight rows of apertures on one side, the other longitudinally striated; zooecial tubes short with diaphragms; no true mesopores. **Ord., Sil.**

***S. reticulata** (Hall) (**99**—21). Generally occurs as fragments of depressed, funnel-shaped zoaria with rounded branches 0.2 to 0.3 mm in diameter, frequently and regularly inosculating; fenestrules about as wide as branches; three irregular rows of zooecia with subcircular apertures and numerous acanthopores; reverse side finely striated. **M. Ord.** (Black River, Trenton): Que.; Vt., N. Y., Pa., Minn.

S. asperato-striata (Hall) (**99**—19, 20). Oval, somewhat unequal fenestrules; outer face roughly striated, inner with three, four, or more rows of subangular zooecia in obliquely parallel lines. **Niagaran:** Ont.; N. Y., and Md. (Rochester), Ind. (Osgood).

PSEUDOHORNERA Roemer 1876

(**Retepora diffusa* Hall). Dichotomously and frequently branching, longitudinally striate on one side, and on other several ranges of tubular zooecia springing from a thin double plate; vestibules expanding from orifices to angular apertures. **Ord., Sil.**

PLATE 99

[Figures are x18 and after Ulrich [CSNH, J 6; Ill G S 8; or Minn G S 3 (1)] unless otherwise indicated.]

1, 2. Batostoma fertile. Vertical and tangential sections. **3, 4. Monotrypa magna.** Tangential and vertical sections (x9). **5–11. Hallopora** spp. **5. H. rugosa** (x1) [Ind G S, An Rp 32]. **6, 7. H. elegantula** [N Y St G, An Rp 14]. A typical specimen (x1) and a portion of the surface much enlarged. **8–10. H. multitabulata.** A typical specimen (x1); surface (x18) showing zooecial closures; surface (x9). **11. H. dalei** [Ind G S, An Rp 32]. A typical specimen (x1). **12, 13. Stromatotrypa ovata.** Typical specimen (x1) and portion of surface enlarged. **14–16. Trematopora tuberculosa.** Vertical section; surface; typical specimen (x2). **17, 18. Pseudohornera diffusa.** Vertical and tangential sections. **19–21. Subretepora** spp. **19, 20. S. asperato-striata.** Tangential section just beneath zooecial apertures, and vertical section. **21. S. reticulata.** A small fragment enlarged to show surface features. **22–30. Fenestrellina** spp. **22, 23. F. elegans** [Pal N Y 2]. A frond (x1), and celluliferous side of another specimen enlarged. **24. F. cestriensis.** Celluliferous side (x9). **25. F. mimica.** Celluliferous side (x9). **26, 27. F. emaciata** [NAIF; after Hall]. Celluliferous and reverse sides (x6). **28. F. stellata** (x6) [Pal N Y 6]. **29, 30. F. tenax.** Different specimens (x18, x9). **31, 32. Semicoscinium** spp. **31. S. planodorsatum.** Celluliferous face somewhat worn (x9). **32. S. tenuiceps,** greatly enlarged [Pal N Y 2]. **33. Loculipora perforata** (x6) [Pal N Y 6]. Celluliferous side, which is partly broken away to show reverse side. **34. Fenestrapora occidentalis.** Surface (x9) showing carina and large pores only. **35–39. Unitrypa** spp. **35–37. U. scalaris** [NAIF; after Hall]. 35: Transverse section of branches, much enlarged, showing rhomboidal sections of branches, with dissepiments connecting them, and the thin expanding carinae connected by scalae. 36, 37: Fragment showing under side of carinae and scalae, and another fragment showing summits of carinae and scalae, the former nodose. **38, 39. U. acaulis** (x6) [Pal N Y 6]. Noncelluliferous side view showing carinae and scalae.

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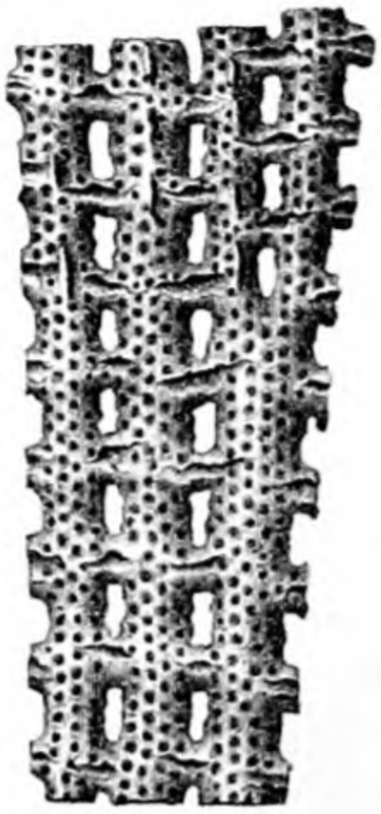
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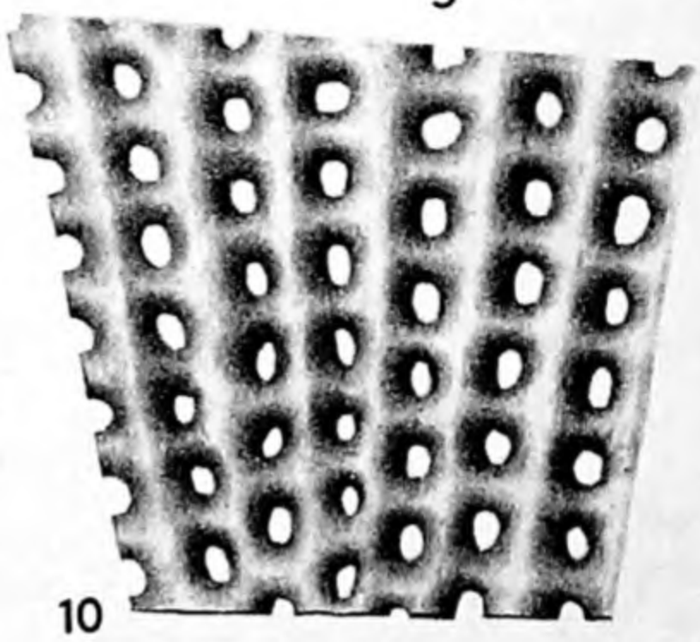
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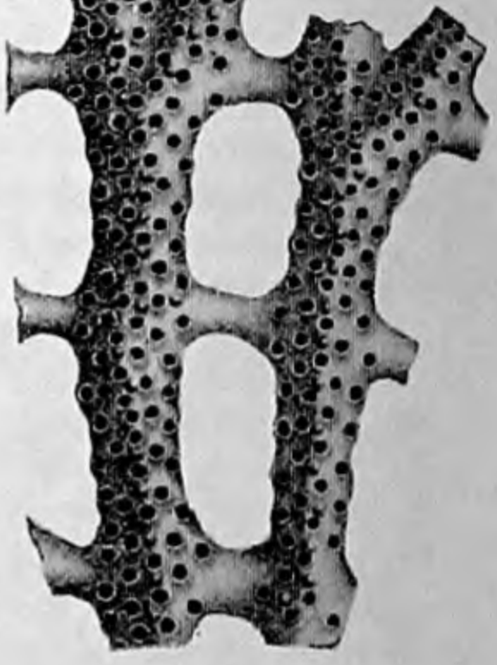
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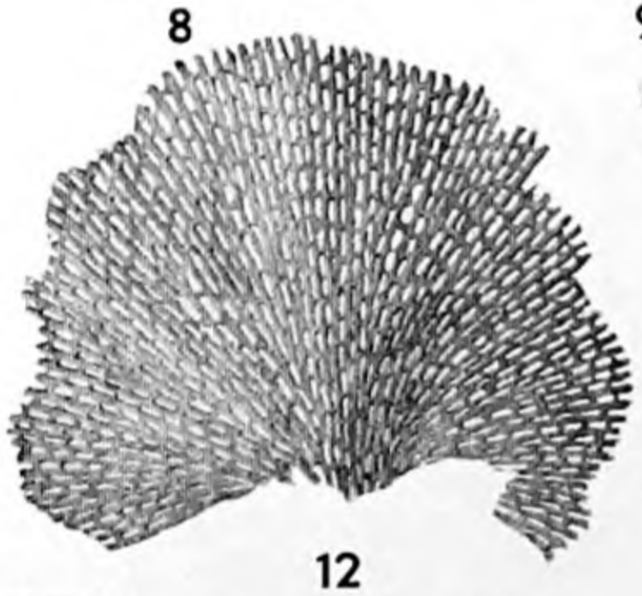
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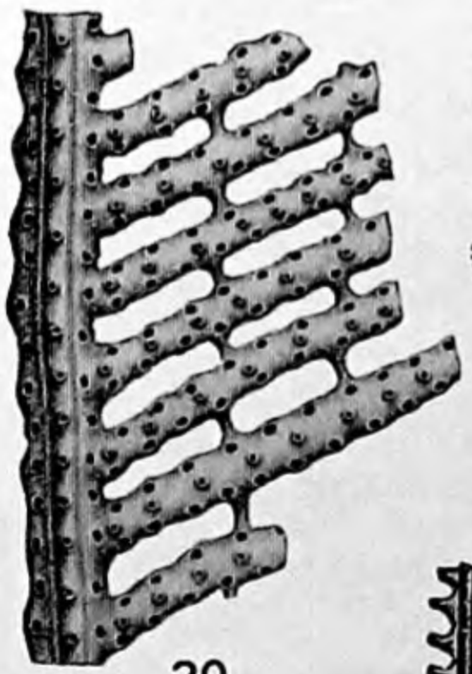
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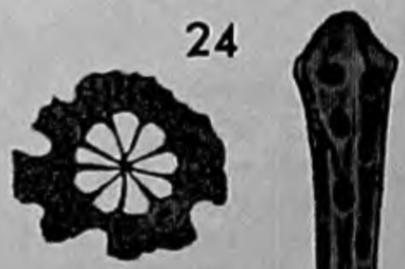
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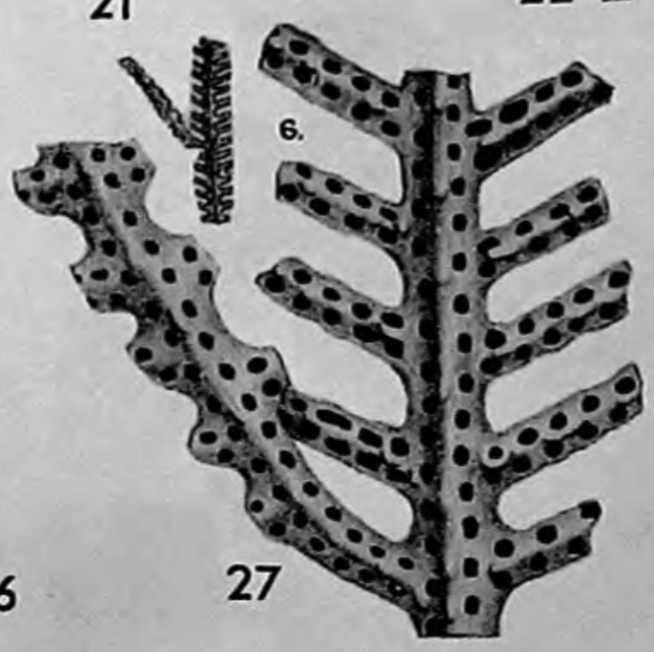
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***P. diffusa** (Hall) (**99**—17, 18). Several stems originate from a common base, forming a shrublike frond; stems frequently bifurcate and spread laterally; apertures quadrangular or subrhomboidal. **M. Sil.** (Rochester): Ont.; N. Y.

FENESTRELLINA Orbigny 1849

(= FENESTELLA of authors, not Bolten 1798)

(**Fenestella crassa* McCoy). Fan- or funnel-shaped, reticulated expansion of straight or flexuous rigid branches; apertures united by noncelluliferous crossbars (dissepiments) at regular intervals; two rows of apertures on inside of branches, separated by a plain or tuberculated median keel. **Sil.–Perm.**

F. elegans (Hall) (**99**—22, 23). Carina subdued; apertures with longer diameters oblique to direction of branches, which are slender and frequently bifurcating, and are united by thin dissepiments; fenestrules on noncelluliferous side, oblong-quadrangular, rarely oval. **M. Sil.:** Ont.; N. Y. (Rochester).

F. stellata (Hall and Simpson) (**99**—28). Characterized by peculiar channeling of branches and dissepiments, and by frequently stellate nodes. **Helderbergian:** Falls of Ohio.

F. emaciata (Hall) (**99**—26, 27). **M. Dev.** (Hamilton): N. Y.

F. cestriensis (Ulrich) (**99**—24). Branches irregularly dividing, slightly flexuous; carina angular; apertures circular, with peristomes; reverse side rounded, smooth except for scattered nodes. **U. Miss.** (Chester): Mississippi Valley region.

F. tenax (Ulrich) (**99**—29, 30). Fenestrules narrower than branches; dissepiments moderately thick; no nodes, but faint striations on reverse side; apertures circular, with peristomes. **U. Miss.,** occurring with preceding.

F. mimica (Ulrich) (**99**—25). **Penn.:** Ind., Ill.

SEMICOSCINIUM Prout 1859

(**S. rhomboideum*). Funnel-shaped; all openings on outer side; wide, short dissepiments, the branches appearing to anastomose on nonporiferous face, whose fenestrules are subrhomboidal or rounded; apertures in two rows; median keel very high, expanded at summit. **Sil., Dev.**

S. tenuiceps (Hall) (**99**—32). Carina sharp and thin; transverse dissepiments do not extend as high as the branches, sometimes scarcely visible; apertures large, round, opening laterally; fenestrule oval on noncelluliferous side, which is striated but appears granular when worn. **M. Sil.:** Ont.; N. Y. (Rochester), Ind. (Osgood).

S. planodorsatum Ulrich (**99**—31). Fenestrules very small; carina prominent, with circular apertures; reverse side flat, with irregularly oval to circular fenestrules, showing no evidence of branching. **M. Dev.:** Falls of Ohio (Onondaga).

FENESTRAPORA Hall 1885

(**F. biperforata*). Differs from *Semicoscinium*, in that reverse of zoarium and expanded summits of carinae are furnished with large scattered pores or pits. **Dev.**

F. occidentalis Ulrich (**99**—34). Fenestrules oval; carina angular and expanded; irregularly disposed pits on side rather few; frond rather coarse. **Hamilton:** Ia. (Cedar Valley).

UNITRYPA Hall 1885

(**Fenestella* (*Hemitrypa*) *lata*). Differs from *Fenestrellina* in having prominent carinae thickened above and connected by thin, oblique, subimbricating plates (scalae) ranging from two per fenestrule to number of zooecia. **Sil., Dev.**

U. scalaris Hall (**99**—35–37). Branches straight, parallel and rigid; carinae and scalae making a ladderlike structure; carinae projecting above the very oblique scalae. **M. Dev.** (Hamilton): Ont.; N. Y.

U. acaulis Hall (**99**—38, 39). Scalae very slender and closely disposed; summit of carina very prominent, sometimes noded; length and width of fenestrules on celluliferous face as three to one; and on noncelluliferous, as two to one. **M. Dev.:** Falls of Ohio (Onondaga).

LOCULIPORA Hall 1885

(**Fenestella perforata*). Funnel-shaped; dissepiments nonporiferous, reduced to a minimum, carinated like the branches; carinae coalesce and expand at summits, their width usually equalling that of branches and dissepiments. **Sil., Dev.**

***L. perforata** (Hall) (**99**—33). Frond regularly reticulated, the fenestrules oval in a depressed hexagonal surface, and each surrounded by 9 to 10 apertures; expansion of carina may make this face appear like the nonporiferous face. **M. Dev.:** N. Y. (Hamilton).

PLATE 100

[Figures are x1 and after Ulrich [Ill G S 8; or Minn G S 3 (1)] unless otherwise indicated.]

1, 2. Hemitrypa proutana. Celluliferous and reverse sides (x9). **3–7. Archimedes** spp. **3. A. wortheni. 4. A. terebreformis. 5. A. communis. 6. A. laxus. 7. A. sublaxus.** Type specimen. **8. Anastomopora perundata** [Pal N Y 6]. Celluliferous side (x6). **9–14. Polypora** spp. **9, 10. P. shumardi** [NAIF; after Hall]. Celluliferous and reverse sides (x6). **11. P. submarginata** (x9). **12, 13. P. incepta** (x1, and enlarged) [Pal N Y 2]. **14. P. elliptica** (x27?) [Kan U Quart 9]. **15, 16. Arthrostylus obliquus** (x18). **17, 18. Thamniscus furcillatus.** Typical specimen, and portion of same (x18), showing celluliferous face. **19–21. Ptilopora** spp. **19, 20. P. cylindracea.** Typical specimen, and portion enlarged (x9). **21. P. striata** (x6) [Pal N Y 6]. **22. Diploporaria bifurcata** (x9). **23, 24. Lyropora quincuncialis.** Poriferous side of network (x9) and obverse side of support. **25. Fenestralia sancti-ludovici** (x9). **26, 27. Penniretopora** spp. **26. P. carinata,** somewhat enlarged. **27. P. conferta.** Typical specimen; portion of celluliferous face enlarged (x9). **28–32. Helopora** spp. **28–30. H. spiniformis.** Surface view; axial and transverse sections (x18). **31, 32. H. harrisi.** Typical complete specimen (x1, x18), and transverse section of a much smaller zoarium (x50).

HEMITRYPA Phillips 1841

(**H. oculata*). Differs from *Fenestrellina* in having a reticulated superstructure whose meshes correspond in position and numbers to the zooecial apertures, and rest on pillars which rise at regular intervals from the moderate median keel of the branches. **Sil.–Miss.**

H. proutana Ulrich (**100**—1, 2). Superficial network of longitudinal bars united by short transverse bars, the former strong over the branches and weaker over the interspaces of underlying frond, the latter alternating in position on opposite sides of each weaker longitudinal bar; underlying branches have each a low carina with circular pores with peristomes on each side, and are connected by depressed dissepiments half as wide as branches. **Miss.** (Keokuk–St. Louis): Mississippi Valley region.

ANASTOMOPORA Simpson 1897

(**Fenestella cinctuta* Hall). Like *Polypora*, but branches anastomose. **Dev.**

A. perundata (Hall) (**100**—8). Fenestrules oval, irregular, noncelluliferous face angular or carinated, celluliferous rounded; cell apertures in three to five ranges. **Hamilton:** N. Y.

ARCHIMEDES (Lesueur) Owen 1842

(**Retepora archimedes* Owen = *A. wortheni* Hall). Like *Fenestrellina*, but spirally wound and supported by a solid calcareous central axis which often is the only part of the zoarium remaining intact. **Miss., Penn.**

***A. wortheni** (Hall) (**100**—3). Screw large and coarse (5 to 10 mm in diameter), volutions either right- or left-handed, five to six in 50 mm; fenestrated portion diverging at about 65°; zooecia separated by strong spinose carina. **M. Miss.:** Ill (Warsaw).

A. communis Ulrich (**100**—5). Central axis or "screw" long, slender (1 to 2 mm in diameter) and uniformly coiled, seven or eight volutions in 20 mm, the fenestrated portion forming an angle of 85 to 90° with axis; **A. intermedius** Ulrich makes an angle of 72° and has somewhat fewer whorls; **S. swallovanus** Hall ranges from 2.8 to 6.7 mm in diameter, and has an average of 5 volutions in 20 mm, the angle of divergence of fenestrated portion being 85°; **A. proutanus** Ulrich has five to seven volutions in 20 mm and an angle of 65° for the fenestrated part, and it is also somewhat thinner than **A. communis.** **U. Miss.** (Chester): All of the above-mentioned species occur in the Southern Appalachians and the Mississippi Valley region.

A. laxus Hall (**100**—6). Very loosely coiled, axis formed of thickened edge of frond; one volution in 25 mm or more; angle of fenestrated portion acute. **U. Miss.** (Chester): Ky., Ill.

A. sublaxus Ulrich (**100**—7). About half the size of preceding. **U. Miss.** (Chester): Ill.

A. terebriformis Ulrich (**100**—4). Differs from *A. communis* in being more slender, with three to four volutions in 20 mm; coiling similar to *A. laxus;* angle of divergence 60 to 65°. Occurs with *A. laxus.*

POLYPORA McCoy 1845

(**P. dendroides*). Differs from *Fenestrellina* in having two to eight rows of zooecia on a branch, and with median keel reduced to a row of strong nodes or tubercles, or absent altogether. **Ord.–Perm.**

P. incepta Hall (**100**—12, 13). Branches regularly dividing with flexuous striae on noncelluliferous side, and several strong ridges separating the three or four rows of oval and alternating apertures on celluliferous side; dissepiments thin, scarcely thickened at junction with branches. **Niagaran:** Ont.; N. Y. (Rochester).

P. shumardi Prout (= **P. cultellata** Hall) (**100**—9, 10). Strong branches united by dissepiments, forming narrow fenestrules on celluliferous side, where branches are marked by sharp nodes, and having three to seven ranges of apertures; reverse side with broad oval fenestrules, and a faint keel or node, or smooth. **M. Dev.:** Falls of Ohio (Onondaga).

P. submarginata Meek (**100**—11). Branches convex with row of spines or tubercles, and five ranges of apertures; five to six apertures per fenestrule, the latter irregular, elongate oval; dissepiments thin. **Penn.:** Ind., Ill., Ia., Neb., Okla., Tex.

P. elliptica Rogers (**100**—14). Variations of species characterized by slowly expanding zoarium and nearly square fenestrules. **Penn.:** Widespread throughout the Midcontinent region.

THAMNISCUS King 1849

(**Keratophytes dubius* Schlotheim). Branches like those of *Polypora*, with few or no dissepiments. **Sil.–Perm.**

T. furcillatus Ulrich (**100**—17, 18). Branches small, with three or four ranges of apertures, with discontinuous or continuous low ridges between. **U. Miss.** (Chester): Ky., Ill.

LYROPORA Hall 1857

(**Fenestella (Lyropora) subquadrans*). Flabellate, the fenestrated portion spread between the arms of a nonporiferous U- or V-shaped calcareous support which is free or pedunculate at base; zooecia in two to five ranges; no median keel. **Dev., Miss.**

L. quincuncialis (Hall) (**100**—23, 24). U-shaped support narrow oval in cross-section; fenestrules irregularly oval; two or three ranges of apertures; stout dissepiments which, on noncelluliferous side, often are stronger than branches, forming transverse ridges. **U. Miss.** (Chester): Ky., Ill., Miss.

FENESTRALIA Prout 1858

(**F. sancti-ludovici*). Differs from *Fenestrellina* in having four rows of apertures, two on each side of a prominent keel. **Miss.**

***F. sancti-ludovici** Prout (**100**—25). Branches with strong central carina dilated into tubercles at intervals; fenestrules oblong, subquadrangular; two

ranges of apertures on each side of carina; dissepiments about two-thirds width of branches. **Miss.** (Warsaw, St. Louis): Ill., Mo.

PENNIRETEPORA Orbigny 1849
(= PINNATOPORA Vine 1883)

(**Retepora pluma* Phillips). Small, delicate stem and short, free lateral branches given off at regular intervals; apertures in two rows on one face only, separated by moderate median keel. **Dev.–Perm.**

P. carinata (Hall) (**100**—26). Small, with broad central axial column, and alternating, thin, short lateral branches; noncelluliferous face with three prominent carinae; apertures circular, with comparatively strong peristomes and prominent carinae between ranges. **M. Dev.:** N. Y. (Hamilton).

P. conferta Ulrich (**100**—27). Central axial column and branches more nearly of same width than in preceding; branches nearly opposite and closely set; two ranges of closely set pores on column and branches, separated by low ridges. **M. Miss.** (Keokuk): Ill., Ia.

PTILOPORA McCoy 1845

(**P. pluma*). Differs from *Penniretepora* in having axial column much stronger than the oblique lateral branches, which occasionally are irregularly united by dissepiments. **Dev., Miss.**

P. striata Hall (**100**—21). Branches rigid, diverging at angles of about 45°, and separated by space twice their width; dissepiments thin, irregular; apertures in two ranges. **M. Dev.** (Hamilton): Ont., N. Y.

P. cylindracea Ulrich (**100**—19, 20). Differs from preceding in having a row of hollow nodes and a median ridge on axial column, a similar row without the ridge on the branches, and very thin, depressed, regular dissepiments. **M. Miss.:** Ky. (New Providence), Ia. (Keokuk).

DIPLOPORARIA Nickles and Bassler 1900

(**Glauconome marginalis* Young and Young). Like *Penniretepora*, but without lateral branchlets. **Miss., Penn.**

D. bifurcata (Ulrich) (**100**—22). Small cylindrical stems 0.3 mm in diameter, bifurcating at regular intervals; apertures in two ranges on side of stem; reverse side of branches finely striated. **U. Miss.** (Chester): Ill.

ARTHROSTYLUS Ulrich 1888

(**Helopora tenuis* James). Bushy, dichotomously divided branches consisting of numerous exceedingly slender, equal, subquadrate segments united by terminal articulations; one face longitudinally striated, the other three (sometimes less) with a linear series of apertures generally between longitudinal ridges. **Ord.**

A. obliquus Ulrich (**100**—15, 16). Segments needle-shaped, about 4 mm long; subquadrangular in cross-section (0.2 by 0.15 mm), slightly expanding to extremity; apertures oblique, lower border prominent; no ridges between ranges. **M. Ord.:** Minn. (Black River–Decorah); Russia.

HELOPORA Hall 1852

(**H. fragilis*). Differs from *Arthrostylus* in its larger segments, which have zooecial apertures on all sides. **Ord.–Dev.**

H. spinifornis (Ulrich) (**100**—28–30). Segments 5 to 10 mm long, obtusely pointed at the end; apertures oblique on all sides, in 8 to 16 longitudinal ranges, and separated by slightly elevated lines. **M. Ord.** (Stones River and Black River): Md., Ind., Tenn., Ill.

H. harrisi James (**100**—31, 32). Segments very small, needlelike, jointed, poriferous on all sides, with zooecia arranged in six longitudinal rows. **U. Ord.:** Ohio (Richmond).

***H. fragilis** Hall. Swollen at one end; apertures oval or subangular, having a spiral direction around stem; length 5 to 6 mm. **L. Sil.** (U. Medinan): Ont.; N. Y.

ARTHROCLEMA Billings 1862

(**A. pulchellum*). Segments celluliferous on all sides, articulated laterally and terminally in pinnate manner; apertures oval in series between longitudinal ridges. **Ord.**

A. armatum Ulrich (**101**—2, 3). Zoarium composed of three sets of joints; secondary and tertiary stems more slender than primary, which have sharply defined articulating sockets and small apertures in six ranges with strong spines near each; secondary segments with apertures in six or five ranges between strong ridges, and with lower lip spiniform. **M. Ord.:** Minn. (Trenton); Estonia.

A. billingsi Ulrich (**101**—1). Primary segments 3.5 to 4.0 mm long, each with two secondary segments (4 mm long) upon each side (four in all), the succeeding ones 2 mm long; apertures subquadrate, six in 2 mm. **Trenton:** Ont.

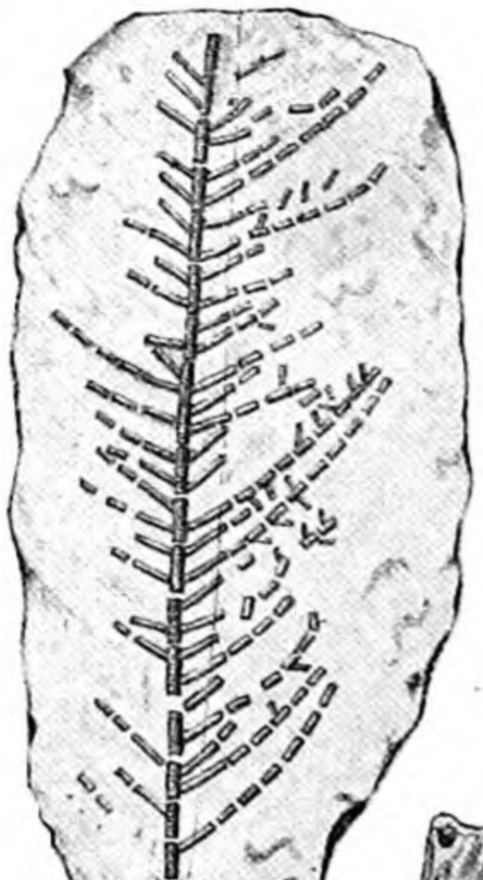
NEMATOPORA Ulrich 1888

(**N. ovalis*). Slender, ramose, with pointed basal extremity, not jointed; subtubular zooecia arranged radially around one or two minute axial tubes, with oval or subcircular apertures, and peristomes generally in linear series between longitudinal ridges. **Ord. Dev.**

***N. ovalis** Ulrich (**101**—12). Bifurcating at intervals of 2 mm, diameter 0.3 to 0.4 mm; large oval apertures, peristomes connected by short ridges, in four or five ranges. **M. Ord.** (Trenton): Que.; N. Y., Minn.; Estonia.

RHOMBOPORA Meek 1872

(**R. lepidodendroides*). Slender, nonarticulate, and solid branches; apertures in longitudinally or diagonally intersecting series; rhombic or diagonal vestibules, in region of which zooecia are thick-walled; acanthopores sometimes of two types, large and small. **Ord.–Perm.**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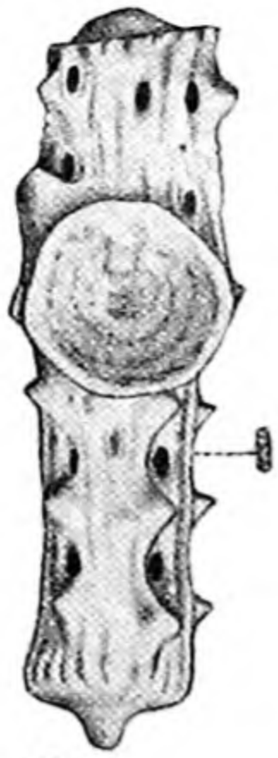
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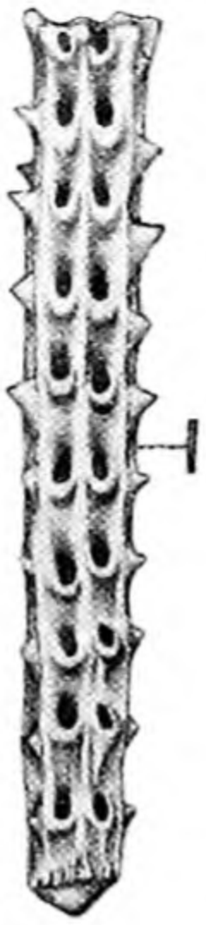
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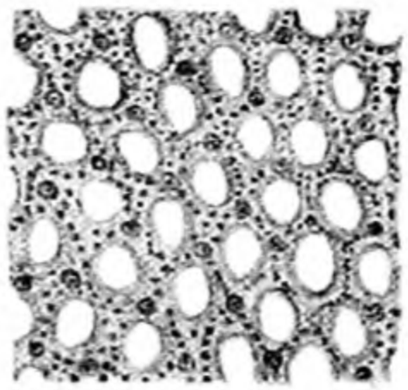
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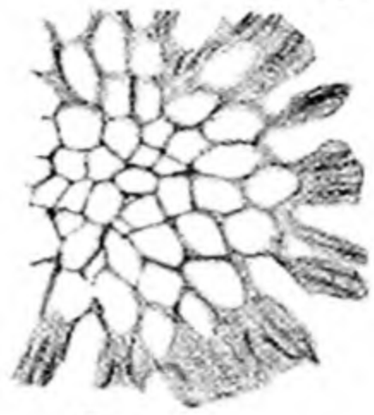
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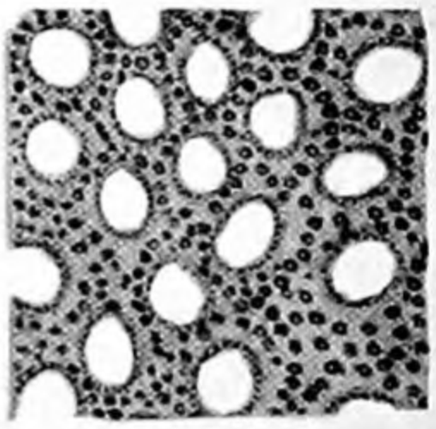
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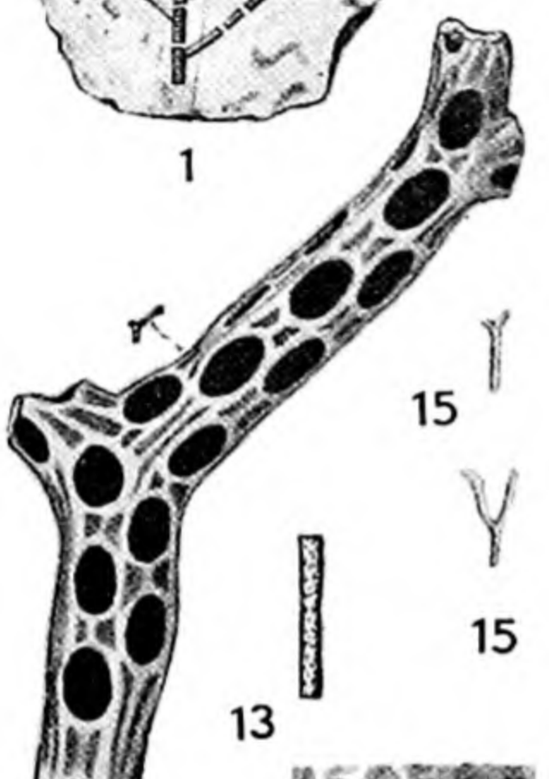
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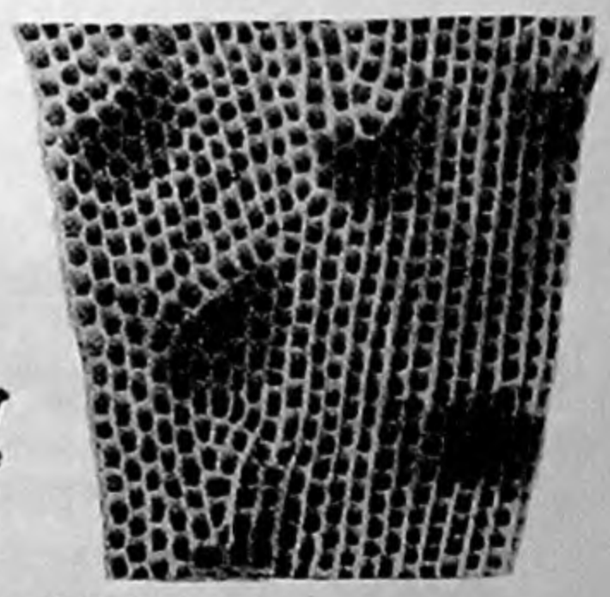
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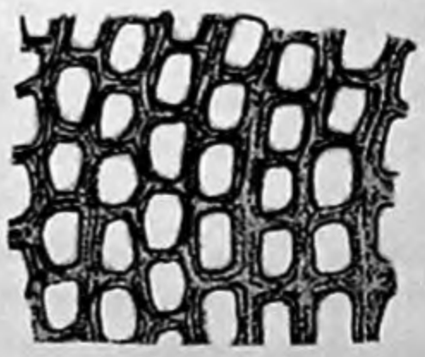
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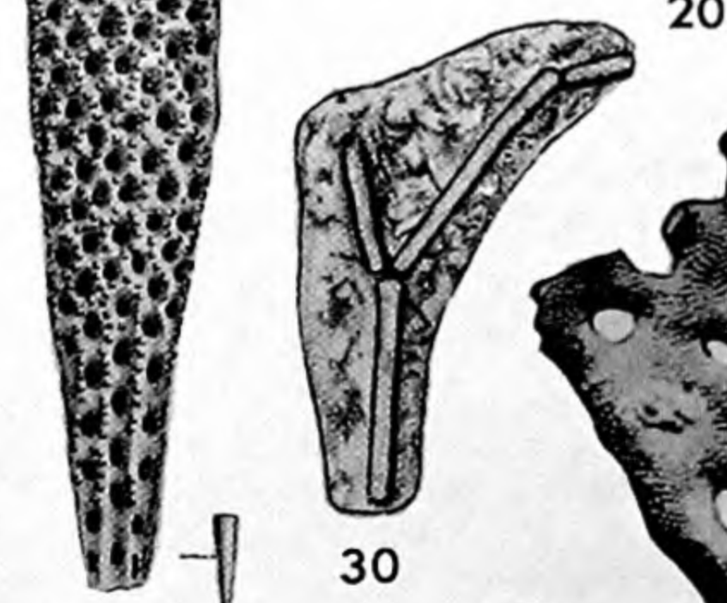
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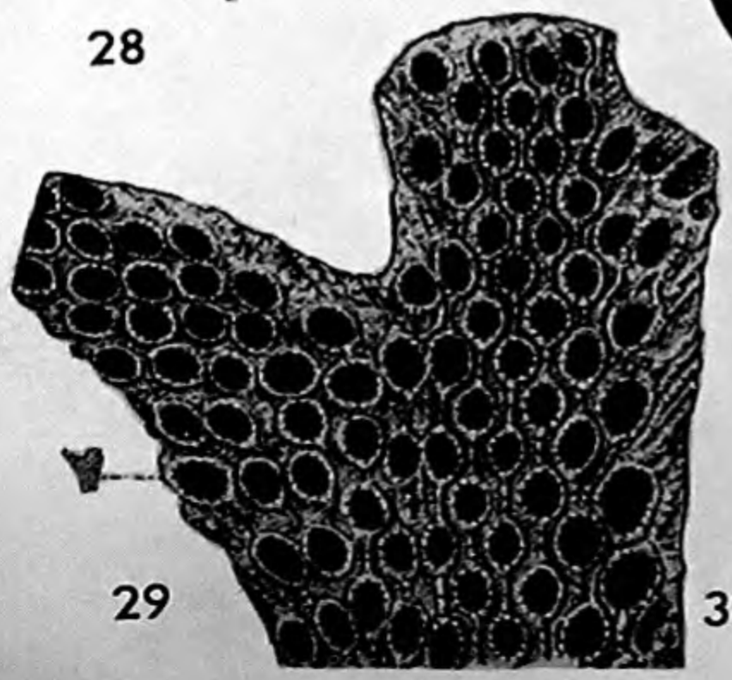
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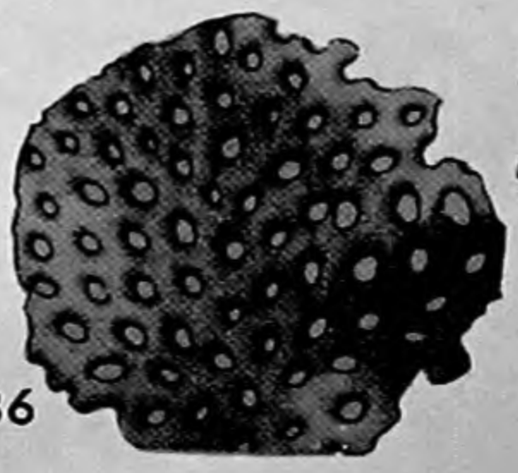
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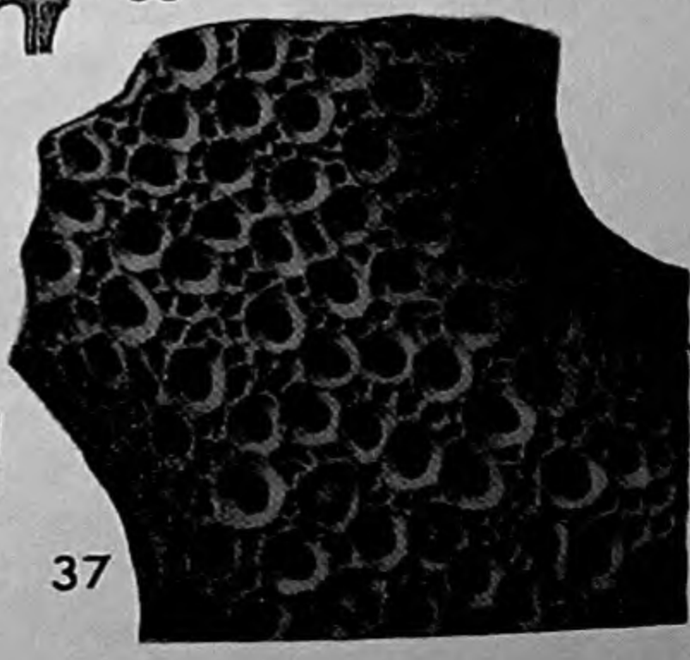
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R. tenuirama Ulrich (**101**—9–11). Branches 0.4 to 0.5 mm in diameter; apertures oval, between slightly flexuous longitudinal ridges, carrying both large and small acanthopores. **U. Miss.:** (Chester) Ky., Ill.

***R. lepidodendroides** Meek (**101**—4–6). Average diameter of branches 1.75 mm, largest 3.0 mm; zooecia in regular quincuncial order, oval, with rhombic vestibules margined by a single row of spiniform tubuli, with a large spine at the angle. **Penn.:** Mississippi Valley region, N. Mex. (Magdalena), Idaho, Nev.

R. crassa Ulrich (**101**—7, 8). Like *R. lepidodendroides* Meek but apertures are larger and not so regularly arranged and large terminal spine is missing. **Penn.:** Mo.

COELOCONUS Ulrich 1889

(**C. rhombicus*). Simple hollow expansions from an attenuated striated base; zooecia short, with well developed hemisepta, and apertures in diagonally intersecting series. **Miss.**

C. granosus Ulrich (**101**—28). Lined on inside with thick epitheca; apertures oval to subcircular, interspaces with granules; basal portion with vertical granulose ridges between oval apertures. **Chester:** Ill.

BACTROPORA Hall and Simpson 1887

(**Trematopora? granistriata* Hall). Like *Rhombopora*, but simple or only slightly branched, and with lower extremity pointed. **Dev., Miss.**

B. simplex Ulrich (**101**—18, 19). Surface with transversely elongated monticules, appearing often like annulations; apertures oval to subcircular; narrow interspaces with a single or double row of small acanthopores; average size 1.5 mm in diameter by 18 mm long. **M. Miss.:** Ill., Ia. and Mo. (Keokuk).

STREBLOTRYPA Ulrich 1890

(**S. nicklesi*). Like *Rhombopora*, with numerous mesopores. **Dev.–Perm.**

S. hamiltonensis (Nicholson) (**101**—13, 14). Apertures between prominent wavy longitudinal ridges, alternating in position in adjoining ranges, and having two angular pits between apertures of each row. **M. Dev.** (Hamilton): Ont.; N. Y., Mich.

***S. nicklesi** Ulrich (**101**—15–17). Apertures small, between three straight longitudinal ridges, alternating; peristomes strongest anteriorly; interspaces with 9 to 15 small pores in two or three rows. **U. Miss.** (Chester): Ky., Ill.

PTILODICTYA Lonsdale 1839

(**Flustra lanceolata* Goldfuss). Simple, unbranched, lanceolate or falciform frond, articulating, with small basal expansion, and having zooecia on both sides except margin; zooecia narrow, oblong-quadrate and arranged longitudinally in young, with additional variously formed zooecia added in adult; walls of vestibule thick, solid, and with double row of minute dots. **Sil., Dev.**

P. nebulosa (Hall) (**101**—35). Thin, leaflike expansion from a thickened, narrow, striated base; rows of zooecia increase rapidly by intercalation; monticules rounded, separated by spaces of about 3 mm. **Helderbergian:** N. Y.

ESCHAROPORA Hall 1847

(**E. recta*). Like *Ptilodictya*, but with apertures in crossed series and surrounded by sloping hexagonal areas. **Ord.**

E. subrecta (Ulrich) (**101**—22–24). Elongate narrow, straight or curved, flattened and tapering below; apertures oval, between regularly wavy ridges which approach and diverge at regular intervals; adult portion with a few mesopores as in *Streblotrypa*. **Black River:** Ont.; Ind., Wis., Minn., Ia.

E. falciformis (Nicholson) (**101**—20, 21). Zoaria sickle-shaped, narrow and long, with apertures rhombic to oval and in curved crossing series. **U. Ord.** (Maysville): Cincinnati region, Tenn.

E. pavonia (Orbigny) (**101**—25, 26). Expanded, more or less irregular; apertures oval to subcircular with hexagonal vestibules and low obscure monticules of slightly larger cells; arrangement of zooecia in curved lines as in preceding, with which it occurs.

CLATHROPORA Hall 1852

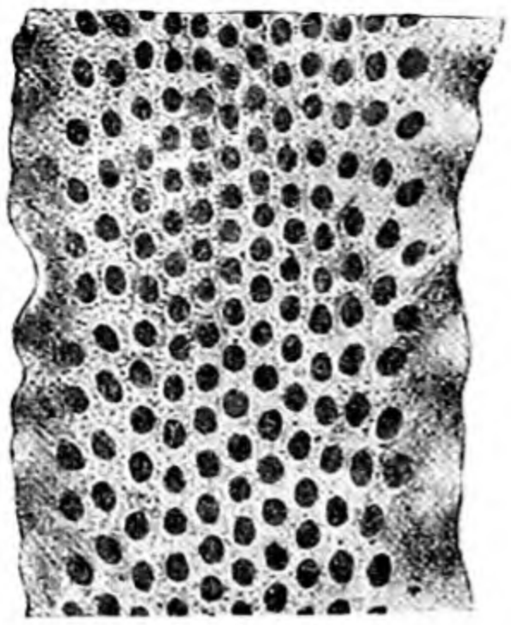
(**C. frondosa*). Anastomosing branches forming regular network with round or oval fenestrules and pointed articulating base; apertures on both sides usually subquadrate, arranged longitudinally. **Sil., Dev.**

***C. frondosa** Hall (**101**—32–34). Flabellate or funnel-shaped fronds, apertures rhomboidal or oblong quadrangular, opening obliquely upward. **Niagaran:** N. Y., Ohio, Ky.

PLATE 101

[Figures are x1 and x18 and after Ulrich [CSNH, J 5, 7; Ill G S 8; or Minn G S 3 (1)] unless otherwise indicated.]

1–3. Arthroclema spp. 1. A. billingsi. Type specimen. **2, 3. A. armatum.** A large primary and a smaller secondary segment. **4–11. Rhombopora. spp. 4–6. R. lepidodendroides.** Tangential, transverse, and vertical sections. **7, 8. R. crassa.** Vertical and tangential sections. **9–11. R. tenuirama** (10 and 11, x12 and x24, respectively). **12. Nematopora ovalis** (x18). **13–17. Streblotrypa spp. 13, 14. S. hamiltonensis** [Pal N Y 6]. A typical specimen, and small portion enlarged. **15–17. S. nicklesi.** Typical zoaria, portion of one enlarged, and longitudinal section. **18, 19. Bactropora simplex.** A complete specimen; portion of surface enlarged (x12). **20–26. Escharopora spp. 20, 21. E. falciformis** (x1.5) [photographs furnished by R. S. Bassler]. **22–24. E. subrecta.** A complete zoarium, and basal and central portions enlarged (x9). **25, 26. E. pavonia.** Typical specimen, and tangential section. **27. Intrapora puteolata** [Pal N Y 6]. Section near margin showing zooecia and noncelluliferous striated margin. **28. Coeloconus granosus.** Complete zoarium (x1, x12). **29–31. Arthropora spp. 29. A. bifurcata. 30, 31. A. simplex.** A specimen consisting of several segments; portion of surface enlarged. **32–34. Clathropora frondosa** [USGS, B 292]. A nearly complete zoarium; vertical section showing bifoliate growth and hemisepta; tangential section. **35. Ptilodictya nebulosa** [Pal N Y 6]. Portion of surface greatly enlarged. **36, 37. Stictoporella cribrosa.** An almost complete zoarium, and portion of surface enlarged.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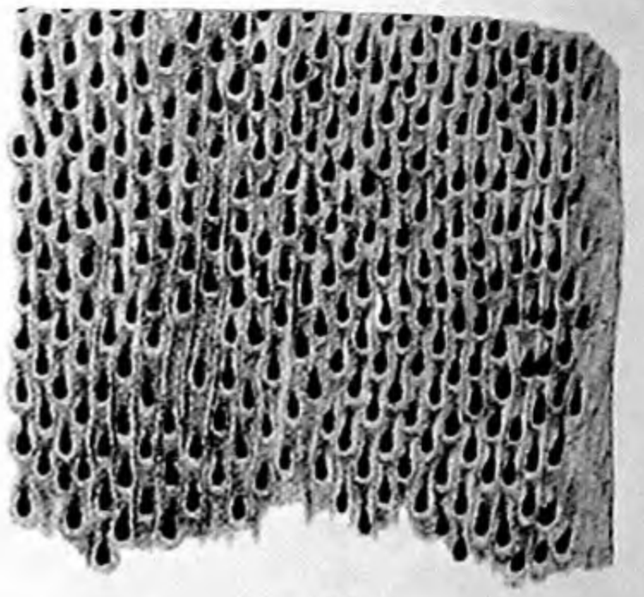
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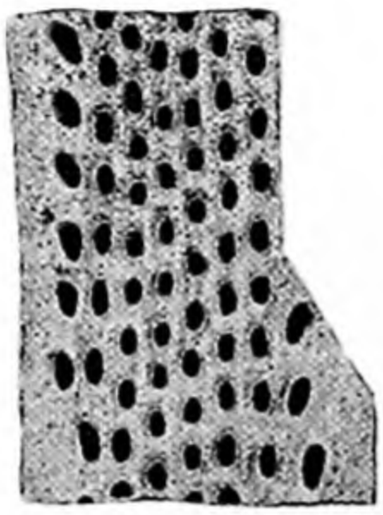
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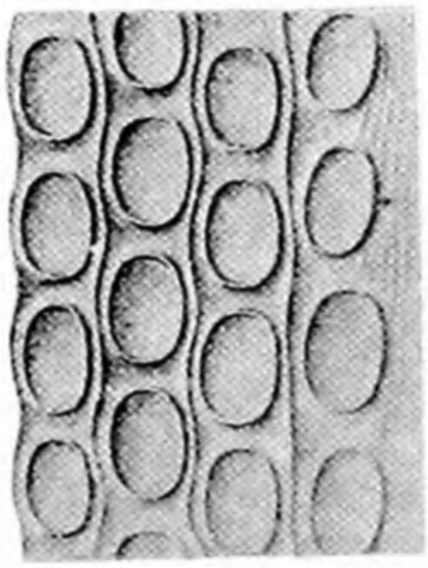
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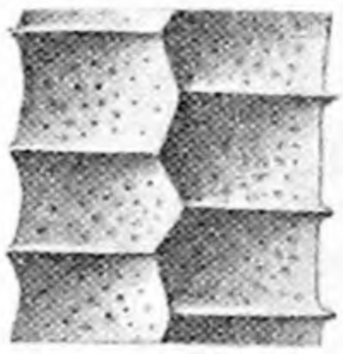
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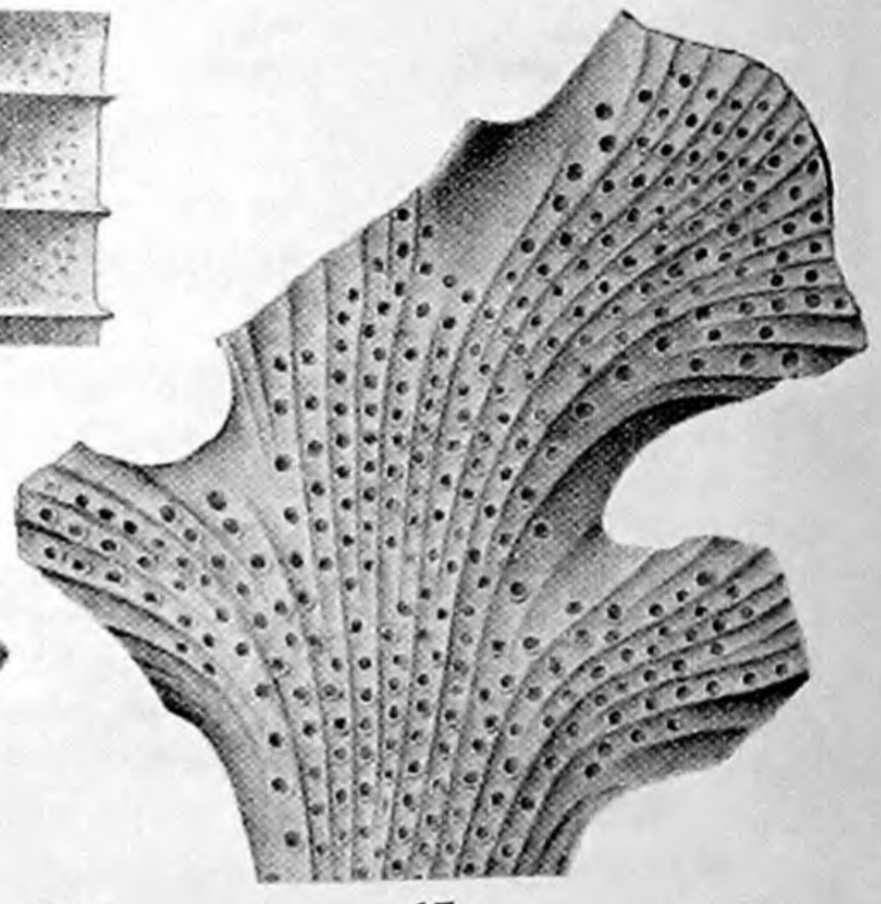
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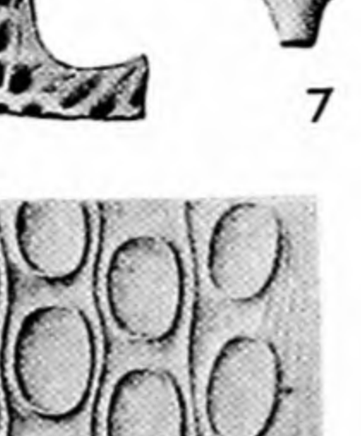
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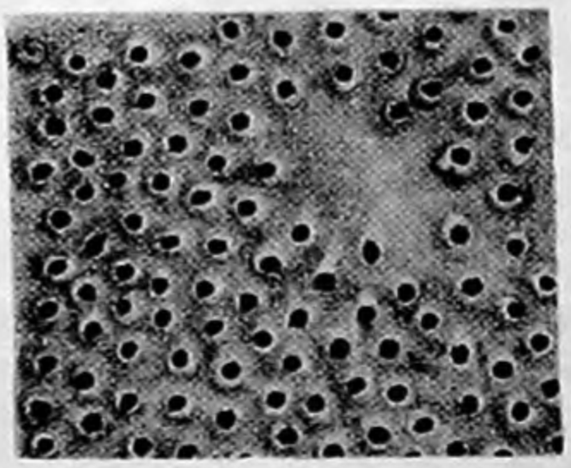
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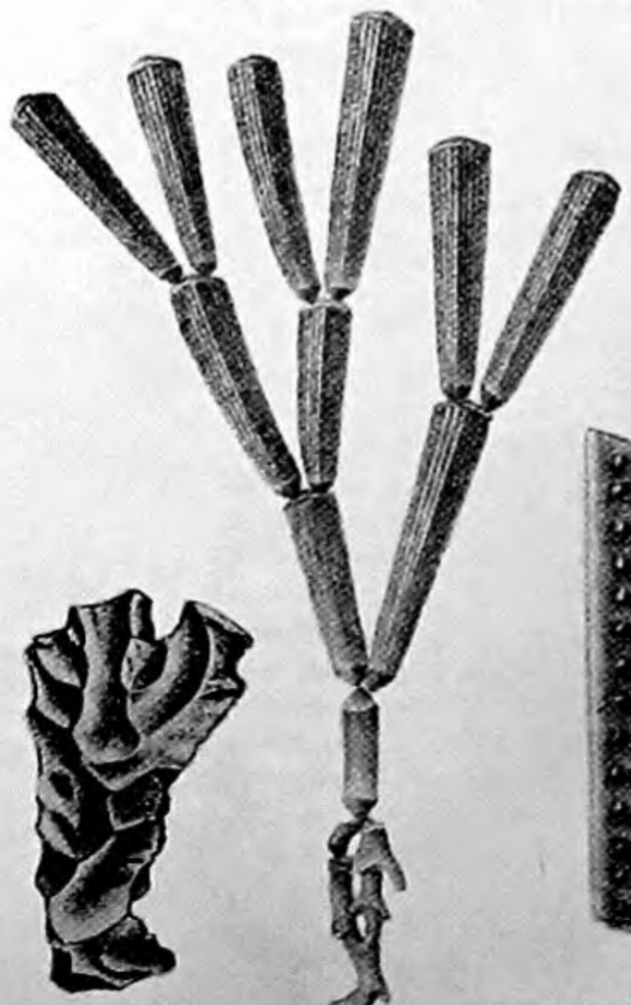
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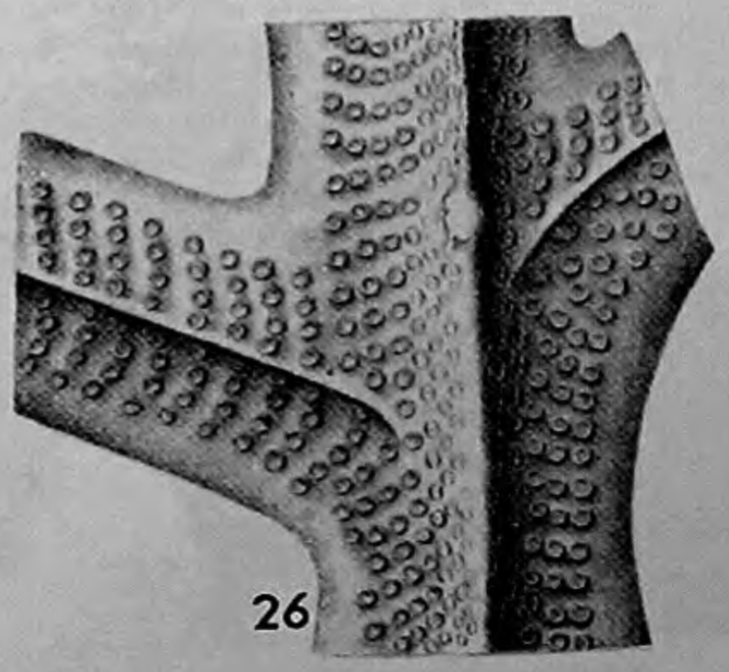
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ARTHROPORA Ulrich 1882

(**Stictopora* (*Ptilodictya*) *shafferi* Meek). Bushy, composed of numerous equal articulating segments spread in a plane; apertures on both sides, elliptical, surrounded by delicate peristomes, and with interspaces marked by variously disposed threadlike ridges and a row of minute papillae. **Ord., Sil.**

A. simplex Ulrich (**101**—30, 31). Jointed, but generally found in isolated, unbranched segments, 12 to 19 mm long and 1 to 1.8 mm wide; margins free from apertures; longitudinal wavy and papillose ridges, alternately converging and diverging, surround apertures. **M. Ord.** (Black River): Minn., Ia.

A. bifurcata Ulrich (**101**—29). Segments small with sharp edges, the lower ones bifurcating; apertures inclosed in distinct granulose rims connecting longitudinally and with only one ridge or line in the interspaces. **M. Ord.** (Decorah): Minn.

***A. shafferi** (Meek). Segments flat, branching repeatedly; apertures oval, rather distant; interspaces with one to four wavy raised lines, visible under high power. **U. Ord.** (Maysville): Cincinnati region.

STICTOPORELLA Ulrich 1882

(**S. interstincta* Ulrich = *Ptilodictya flexuosa* James). Branching and leaflike, nonarticulate from spreading base; zooecia on both sides, with primitive portion tubular, usually long, generally without septa except occasionally an inferior one; apertures at bottom of wide sloping vestibule; thick-walled, untabulated mesopores on margins of fronds and between apertures. **Ord.**

S. cribrosa Ulrich (**101**—36, 37). Fenestrules at irregular intervals and varying greatly in size and form; apertures small, subcircular or elliptical, with sharply defined polygonal or circular vestibules and numerous small mesopores which often completely surround the zooecia. **M. Ord.** (Black River-Decorah): Minn.; Estonia.

INTRAPORA Hall 1883

(**I. puteolata*). Ramose from a spreading base, with compressed and dichotomously divided branches; zooecia on both sides, tubular, at first parallel to mesotheca, then bending abruptly outward; apertures oval, with peristome; minute angular pits, the openings of tabulated mesopores, in the interspaces, sometimes closed by calcareous material. **Dev., Miss.**

***I. puteolata** Hall (**101**—27). Flattened, dichotomously branching frond from spreading base; zooecia resting upon mesotheca, with rather long direct vestibule and irregularly disposed circular apertures; spaces between vestibules and margins of fenestrules occupied by numerous tabulated mesopores which open to surface as fine pits. **M. Dev.:** Falls of Ohio (Onondaga).

RHINIDICTYA Ulrich 1882

(**R. nicholsoni*). Bifoliate ramose, of narrow compressed, bifurcating, straight-edged branches with parallel margins, attached by continuous expanded base; apertures between longitudinal, slightly elevated or flexuous ridges, carrying a crowded row of small blunt spines; space around apertures sloping to summit or ridges. **Ord., Sil.**

R. mutabilis Ulrich (**102**—6, 7). Branches commonly 2.3 to 3.2 mm wide, dividing at intervals of 7 to 16 mm; noncelluliferous margins often almost wanting; zooecia in 14 or 15 rows, the intervening ridges carrying granules; apertures direct. **M. Ord.** (Black River, Trenton): Ind., Minn., Ia.; Estonia.

PHYLLODICTYA Ulrich 1882

(**P. frondosa*). Bifoliate, simple or irregularly branched, from an expanded base; long tubular zooecia with diaphragms, but without hemisepta, bending very gradually outward from central axis, forming oblique apertures with posterior edge liplike; wide subsolid interspaces, traversed vertically by minute tubuli, which appear as papillae on surface. **Ord.**

P. varia Ulrich (**102**—8–10). Leaflike expansions, surface with smooth or finely granulated and striated maculae at 4 mm intervals; apertures pyriform, oblique, with peristome strong posteriorly; granulose vertical ridges between apertures. **M. Ord.** (Black River): Ont.; Minn.; Estonia.

PACHYDICTYA Ulrich 1882

(**P. robusta*). Bifoliate, ramose of narrow bifurcating stems with parallel margins, or irregular undulating fronds with acute, nonporiferous margins; surface with small maculae, surrounded by apertures slightly larger than average; marginal rows of apertures sometimes larger than average; zooecia thin-walled, elliptical or subquadrate, separated by small

PLATE 102

[Figures are x1 and after Ulrich [Ill G S 8; or Minn G S 3 (1)] unless otherwise indicated.]

1–5. Pachydictya spp. **1, 2. P. fimbriata.** Typical specimen, and portion of surface enlarged (x9). **3, 4. P. acuta.** Typical specimen; enlarged portion of another zoarium (x9). **5. P. crassa** [Pal N Y 6]. Portion of surface (x18) showing zooecia. **6, 7. Rhinidictya mutabilis.** Enlarged surface (x9) showing arrangement of zooecia, and a typical zoarium. **8–10. Phyllodictya varia.** A fragmental zoarium; portions of surface (x18, x9) showing papillose character of ridges. **11. Scalaripora scalariformis** (x6) [Pal N Y 6]. A view looking directly on one of the angles, showing angular margins, scalae of two of the faces, and zooecial apertures. **12–14. Coscinium** spp. **12. C. latum.** A nearly complete zoarium preserving expanded base and most of perforated frond. **13, 14. C. cribriforme.** An incomplete zoarium [Pal N Y 6]; section (x18) showing marginal row of zooecia. **15–17. Sulcoretepora** spp. [Pal N Y 6]. **15. S. gilberti** (x6). **16, 17. S. incisurata.** An almost complete zoarium, and a portion enlarged (x6) to show surface. **18. Glyptopora sagenella.** A typical specimen. **19, 20. Acrogenia prolifera** [Pal N Y 6]. A frond showing rootlets and manner of growth, and a portion of surface enlarged (x6). **21. Prismopora triquetra** [Pal N Y 6]. Enlarged specimen (x6) showing concave face and zooecial apertures. **22–24. Dichotrypa lyroides.** Specimen showing thick rounded base; end view of same; surface (x9). **25, 26. Taeniopora exigua** [Pal N Y 6]. An almost complete zoarium; a portion enlarged (x6) showing two faces of triangular main branch and two flattened lateral branches.

vesicles; vestibules direct, thick-walled, ringlike in section; interspaces with minute tubuli; one or more diaphragms present. **Ord., Sil.**

P. fimbriata Ulrich (**102**—1, 2). Branches 2 to 5 mm wide, with subparallel, wavy or ruffled nonporiferous margins; apertures in rows in central area, between lines of minute pores. **M. Ord.** (Black River): Minn.; Estonia.

P. acuta (Hall) (**102**—3, 4). Differs from *P. fimbriata* in its smooth nonporiferous margin and greater interspaces between apertures, which are much larger near margin than at center. **M. Ord.** (Trenton): Ont.; N. Y., Ky., Minn., Ia.; Man.

P. crassa (Hall) (**102**—5). Branches 2.5 to 3.0 mm wide; cells elliptical with strong peristome and separated by slightly wavy ridges; a marginal row of larger apertures, with noncelluliferous striated margin. **L.** and **M. Sil.:** Anticosti; Ont.; N. Y. to Tenn.

SULCORETEPORA Orbigny 1849
(= CYSTODICTYA Ulrich 1882)

(**Flustra parallela* Phillips). Ramose, narrow, bifoliate branches, with lunaria and vesicles. **Dev.–Perm.**

S. gilberti (Meek) (**102**—15). Repeatedly branching rows of apertures and separating ridges, increasing rapidly by interpolation on the branches. **M. Dev.** (Onondaga): Ont.; Mich., Ohio, Ind., Ky.

S. incisurata (Hall) (**102**—16, 17). Branches bifurcating, 2 to 6 mm wide, margins parallel or slightly diverging; ridges continuous to margin, where they often cause denticulations, slowly increasing by intercalation; apertures circular to oval or irregular; lunaria strong. **M. Dev.** (Hamilton): Ont.; N. Y.

DICHOTRYPA Ulrich 1889

(**D. foliata*). Like *Sulcoretepora*, but in form a large, thin, bifoliate expansion with solid maculae on surface. **Dev., Miss.**

D. lyroides Ulrich (**102**—22–24). Frond free, lyre-shaped, with thick, solid, rounded margins; surface with broad monticules, with solid circular or substellate maculae bordered by larger cells. **M. Miss.:** Ky. (St. Louis).

TAENIOPORA Nicholson 1874

(**T. exigua*). Differs from *Sulcoretepora* in having strongly elevated, longitudinal central ridge on each face. **Dev.**

***T. exigua** Nicholson (**102**—25, 26). Noncelluliferous margin comparatively narrow, carinae on main stem and branches strong, rounded; apertures circular, with strong peristomes. **Hamilton:** Ont., N. Y.

COSCINIUM Keyserling 1846

(**C. cylops*). Differs from *Sulcoretepora* in having branches inosculating at short intervals, so as to produce broad fronds, perforated at regular intervals by elliptical or circular fenestrules. **Sil.–Perm.**

C. cribriforme Prout (**102**—13, 14). Cells tubular, very oblique, the apertures trilobate or when worn, arched or subtriangular, closely and irregularly disposed; fenestrules varying greatly in size and distance from each other; lunaria elevated. **M. Dev.** (Onondaga): Ohio, Ind., Ky., Ala.

C. latum Ulrich (**102**—12). Branches wider than in *C. cribriforme* (4 to 5 mm): zooecial apertures elevated and disposed in diagonal lines. **M. Miss.** (Burlington): Ill., Ia.

ACROGENIA Hall 1883

(**A. prolifera*). Segmented, arising from cylindrical rootlets, two segments from truncated ends of preceding one, each obconical and striated at base, later becoming flattened and bearing apertures in linear series, separated by ridges, largest in marginal row; lunaria prominent. **Dev.**

***A. prolifera** Hall (**102**—19, 20). Apertures small and circular, with weak peristomes, and in rows, separated by continuous longitudinal ridges. **Hamilton:** N. Y.

PRISMOPORA Hall 1883

(**P. triquetra*). Ramose, of triangular bifurcating or trifurcating branches. **Dev.–Penn.**

***P. triquetra** Hall (**102**—21). Faces of branches 3 to 6 mm wide, concave; apertures in diagonal transverse rows from center of face; peristomes prominent posteriorly; relatively wide noncelluliferous margins; bifurcating branches frequent. **M. Dev.** (Onondaga): Falls of Ohio.

SCALARIPORA Hall 1883

(**S. scalariformis*). Like *Prismopora*, but with faces of triangular branches crossed by salient transverse ridges. **Dev.**

***S. scalariformis** Hall (**102**—11). Faces of branches 3.5 to 4.0 mm wide, ray concave, transverse ridges at intervals of 1.5 mm and having a height at center of face of 1 mm; celluliferous; apertures circular, with pronounced peristomes, irregularly disposed. **Onondaga:** Falls of Ohio.

GLYPTOPORA Ulrich 1884

(**Coscinium plumosum* Prout). A thin expansion with salient ridges or crests on both surfaces, uniting into cuplike cavities; ridges sometimes pronounced and leaflike, composed of two layers of zooecia arising from a mesotheca; upper surface with solid maculae. **Miss.**

G. sagenella (Prout) (**102**—18). Cups elongate, often groovelike; summit of ridges sharp, nonporiferous; apertures subcircular, with unequal peristomes. **M. Miss.:** Ill. (Warsaw), Ia. (Keokuk).

EVACTINOPORA Meek and Worthen 1865

(**E. radiata*). Free, of four or more vertical leaves of cruciform or stellate arrangement; rays united, thick, and nonporiferous in basal portion, and free with subcircular apertures on both sides in upper part; vesicular interspaces, solid at surface. **Miss.**

E. grandis M and W (**103**—12). Large, transverse

diameter probably 175 mm (7 in.); rays four; apertures small, regularly arranged in quincunx, separated by about twice their width. **Burlington:** Ill., Ia.

E. radiata M and W (**103**—8–11). Rounded below, above with eight solid subcarinate rays having circular pores on thin portions; greatest diameter, from tip to tip of rays, 22.5 mm. **New Providence:** Ky., Mo.

ACTINOTRYPA Ulrich 1889

(**Fistulipora peculiaris* Rominger). Thin, bifoliate expansion with 8 to 10 vertical, septalike ridges in aperture, extending along sides of vestibule. **Miss.–Perm.**

***A. peculiaris** (Rominger) (**103**—7). Apertures regularly arranged in diagonal intersecting series, floriform from toothlike projection of pseudosepta; peristomes raised; minutely punctured or granular subcircular maculae characterizing surface at variable intervals. **M. Miss.** (Keokuk): Ill., Ia., Mo.

WORTHENOPORA Ulrich 1889

(**W. spinosa*). Bifoliate, branching or palmate, with regularly arranged elongate rhomboidal zooecia with semi-elliptical apertures, the truncated posterior margin somewhat raised; line of junction between zooecia marked by ridge; plain, elongate triangular space below aperture. **Miss.**

***W. spinosa** Ulrich (**103**—15, 16). Elongate branches 3 to 4 mm wide and 0.5 to 0.8 mm thick; acutely elliptical in section; margins subparallel, with a series of slender spines pointing obliquely upward. **Keokuk:** Ill., Ia.

LICHENALIA Hall 1852

(**L. concentrica*). Subcircular, unilaminar expansion, with prostrate elongate, subrhomboidal zooecia having direct subtubular vestibule and rounded apertures with peristome much elevated on posterior side. **Sil.**

L. concentrica Hall (**103**—4). Cuplike when young, flattened in maturity, and variously contorted from irregular growth or by accident; concentrically striate and rugose surface on noncelluliferous side; apertures in concentric lines, opening on summit of elevated pustules. **Niagaran:** Ont.; N. Y., Ind.; Estonia.

DIAMESOPORA Hall 1852

(**D. dichotoma*). Ramose, of hollow stems, lined internally by epitheca; simple hexagonal or rhomboidal zooecia with oval apertures in anterior half forming with growth tubular vestibules, separated by compact or horizontally laminated interspaces; peristomes equally elevated, or highest posteriorly. **Sil.**

***D. dichotoma** Hall (**103**—1–3). Regularly bifurcating, generally filled with rock matrix or crushed; interior of hollow branches transversely striated, apertures in regularly ascending spiral lines, strongly elevated posteriorly. **Rochester:** Ont.; N. Y.

STICTOTRYPA Ulrich 1890

(**S. similis*). Ramose, not pointed at base; branches dichotomously dividing, narrow, compressed, with circular or elliptical apertures, evenly elevated peristomes, and flat or concave interspaces of horizontally laminated solid material. **Sil.**

S. punctipora Hall (**103**—5, 6). Flattened, bifurcating; apertures minute, punctiform, with elevated peristomes arranged in diagonal series. **M. Sil.:** Ont.; N. Y. (Rochester), Ind. (Osgood).

PALESCHARA Hall 1874

(**P. incrustans*). Thin incrustations with short, direct, generally thin-walled zooecia with long, hexagonal or polygonal apertures. **Sil., Dev.**

***P. incrustans** Hall (**103**—21). On shells (*Spirifer lamellosus*) or other bodies; 0.1 to 1.0 mm thick, cells polygonal in contact; walls thick, sometimes with obtuse spinose processes at the angles. **Helderbergian:** N. Y.

Order Cheilostomata. Zooecia calcareous or chitinous, of various forms, arranged side by side, with more or less of anterior aperture of smaller dimension than zooecium and closed by a movable operculum, appearing often to occupy entire surface of zoarium owing to noncalcification of front wall and its removal in fossilization. **Mesozoic–Recent.**

MEMBRANIPORINA Levinsen 1909

(There is no genotype, as this "genus" represents an artificial group of Membraniporae which are incompletely known.) Incrusting, irregular calcareous or partly calcareous expansions; zooecia regularly arranged or in rows, exhibiting neither ovicells nor avicularia, and with variously shaped apertures, according to degree of calcification of zooecial front wall. **Cret.–Recent.**

PERIPOROSELLA Canu and Bassler 1917

(**P. tantilla*). Each zooecium surrounded by 12 to 16 dietellae arranged all around aperture and communicating with two large septulae. **Cret.–Eoc.**

P. plebeia (Gabb and Horn) (**103**—19). Incrusting, sometimes on *Coscinopleura digitata*; cells generally in radiating lines, elongate to pyriform, separated by depressed lines; apertures large; oral openings occupying whole cellule. **M. Eoc.:** N. J. (Rancocas).

P. rimulata (Ulrich) (**103**—20). Zooecia hexagonal, arranged quincuncially with longitudinal rows generally regular; apertures occupying entire cell, quite regularly ovate in form; interapertural space narrowed and rounded, sometimes angular, often with depressed central line. **L. Eoc.:** Md. (Aquia).

CONOPEUM Gray 1848

(**Membranipora lacroixii* Savigny-Audouin). Ovicells, dietellae and avicularia absent; margins of mural rim wholly granulated; septula distal and multiporous; two or three lateral septulae present;

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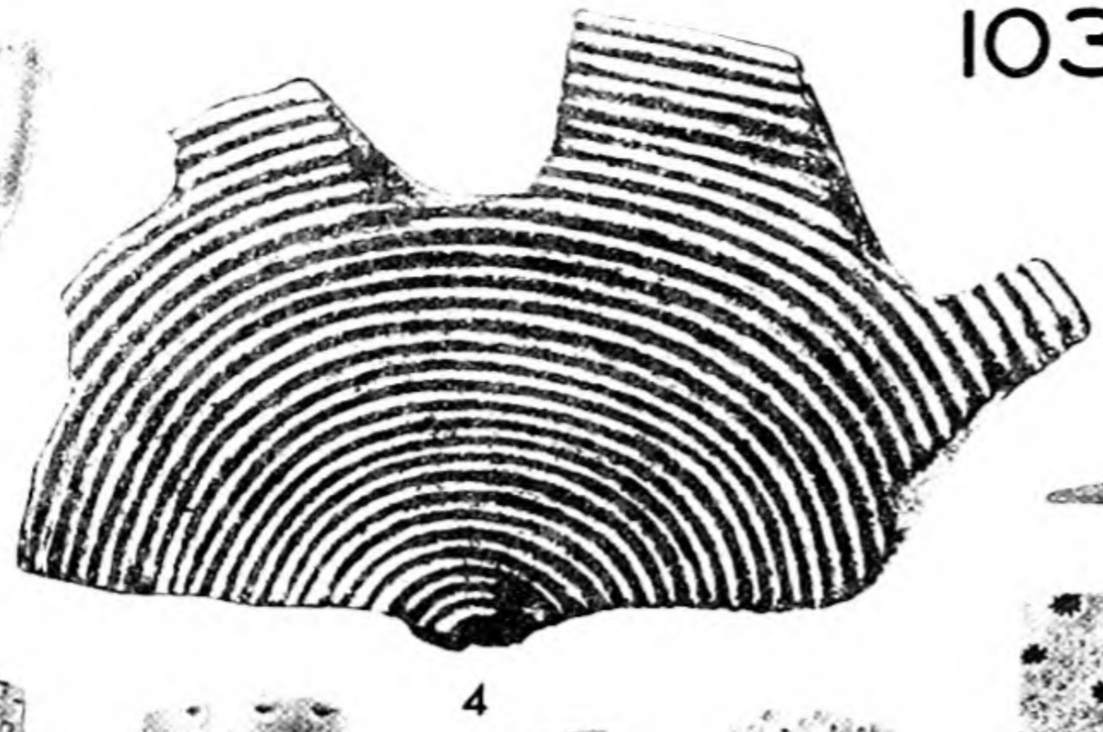

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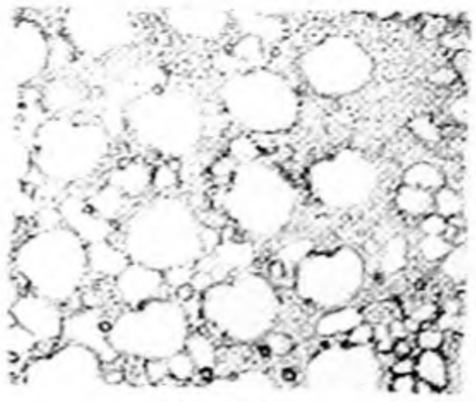

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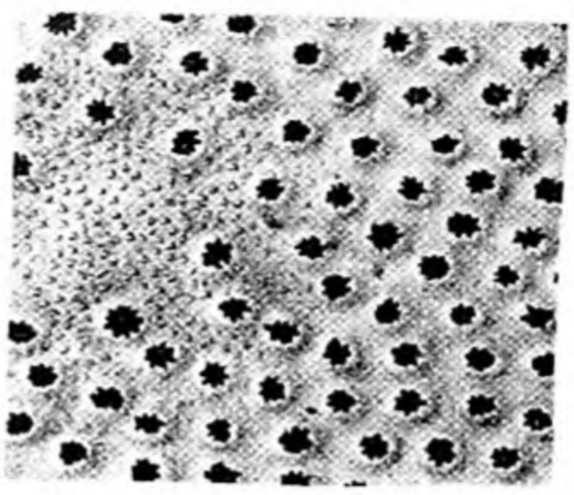

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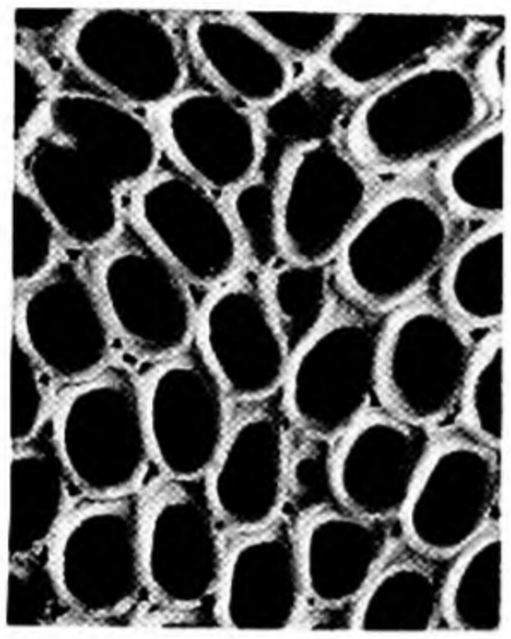

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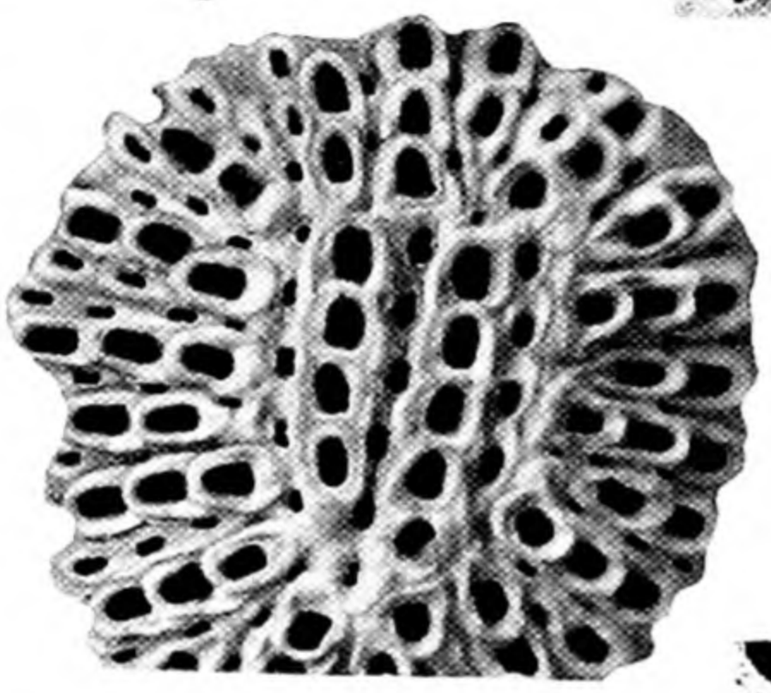

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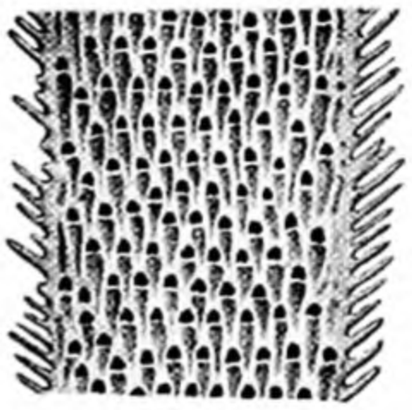

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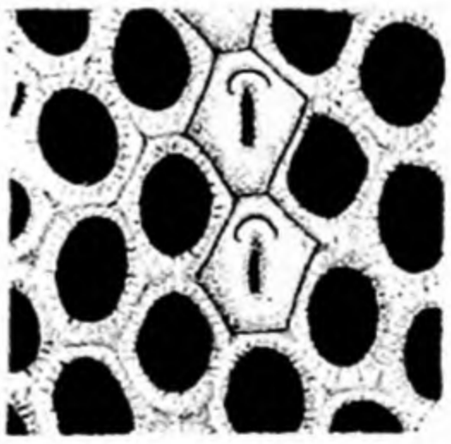

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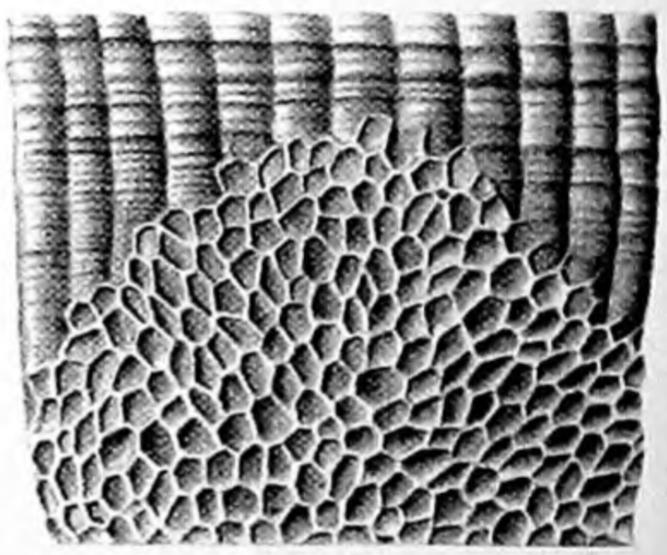

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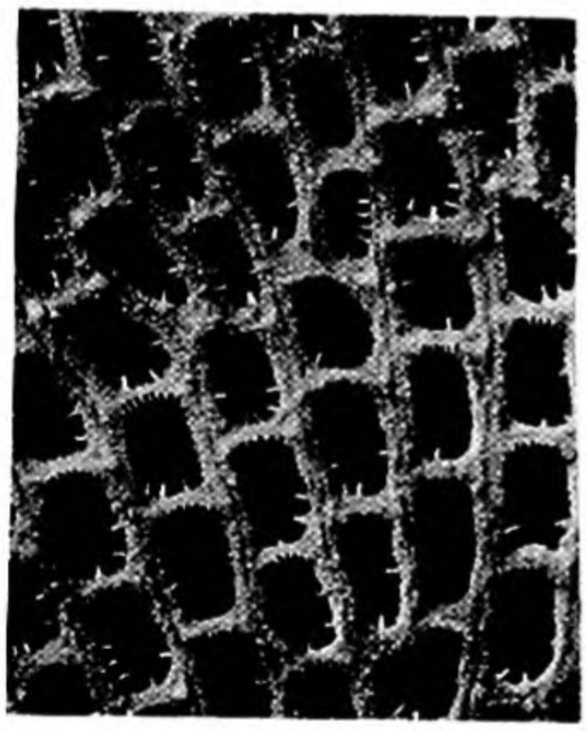

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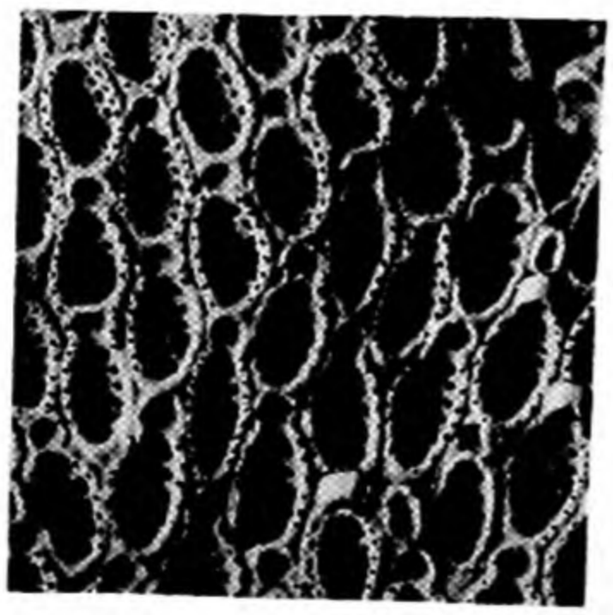

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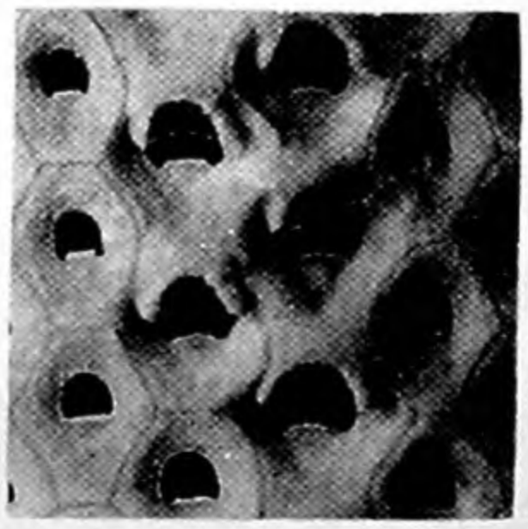

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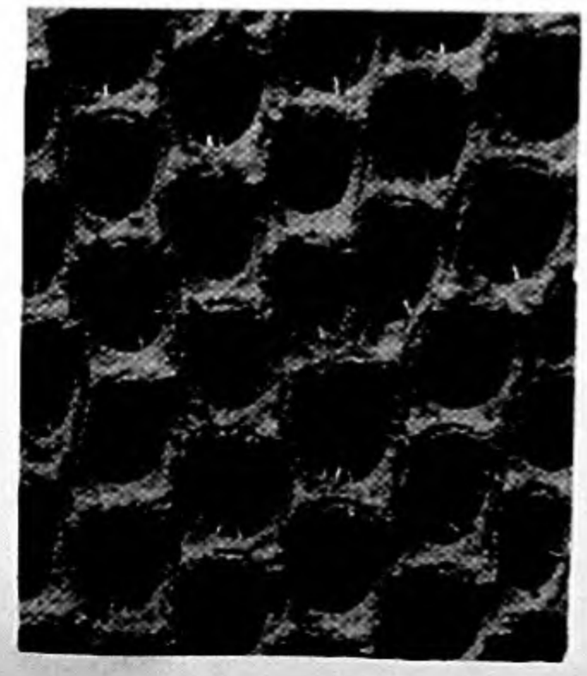

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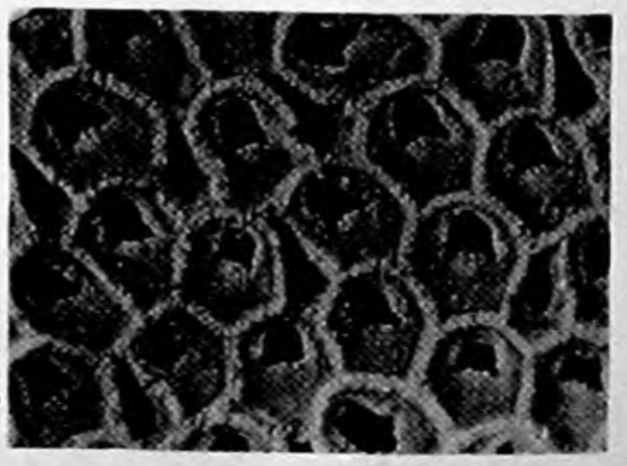

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triangular hollows between separate apertures having special walls. **U. Cret.–Recent.**

C. lamellosum Canu and Bassler (**103**—13). Zoaria consisting of large undulating fronds formed of multiple lamellae growing back to back; zooecia distinct, somewhat elongate; mural rim flat. **Eoc.:** Miss. (L. Jackson).

ACANTHODESIA Canu and Bassler 1920

(**Flustra savartii* Savigny-Audouin). Zoarium incrusting or free and subcylindrical, unilaminar or bilaminar; zooecia surrounded at times by a sort of collar, the surface of which may be tuberculate; spines project from walls into opening; ovicells absent. **Eoc.–Recent.**

***A. savartii** (Savigny-Audouin), forma **bifoliata** Ulrich and Bassler (**103**—18). This species has been divided into a number of forms; forma **bifoliata** has a bilaminar zoarium and a thin mural rim. **Mioc.:** Md. (Choptank).

A. oblongula Ulrich and Bassler (**103**—17). Zoarium incrusting shells; zooecia distinct, separated by a furrow of little depth; mural rim rounded, granular, ornamented by two large distal tubercles. **Mioc.:** Md. (Calvert, Choptank).

DISCOPORELLA Orbigny 1852

(**Lunulites umbellata* Defrance). Zoarium discoidal, with vibracula; zooecia with 2 rounded opesiules and spines free or joined together. **Mioc.–Recent.**

***D. umbellata** (Defrance) (**103**—24). Zooecial spines joined together to form a cribriform opening. **Mioc.–Recent:** Atlantic and Gulf regions; Europe.

TROCHOPORA Orbigny 1849

(**Lunulites conica* (Defrance) Michelin). Zoarium free, conical; zooecia and vibracula in distinct rows; growth of zoarium effected by superimposed disks with zooecia arranged in single rows; vibracula symmetrical. **Eoc.–Mioc.**

T. bouei Lea (**103**—14). Zooecia pyriform, distinct; mural rim projecting distally. **Eoc., Olig.:** Ala. to Tex. (Claiborne), Miss. (L. Jackson and Vicksburg).

COSCINOPLEURA Marsson 1887

(**Eschara elegans* Hagenow). Aperture semilunar, rounded in front, straight behind; frontal without pores or avicularia; margin of zoarium bordered by large vibracula. **Cret.–Eoc.**

C. digitata Morton (**103**—22). Branches compressed, acutely elliptical, bifurcating, somewhat twisted, 2.5 to 3.0 mm wide; zooecia hexagonal, about 0.55 mm long and 0.38 mm wide, regularly arranged in quincunx, bounded by a slightly impressed line, apertures in front of center; small subcircular cells (avicularia) on margins of zoarium and below bifurcation. **M. Eoc.:** N. J. (Rancocas), Md. (Aquia).

VELUMELLA Canu and Bassler 1917

(= DIPLOPHOLEOS Canu and Bassler 1917)

(**Velumella* (*Onychocella*) *levinseni*). Mural rim not separated from cryptocyst; zooecium closed by operculum whose axis of rotation is indicated by two inwardly projecting points; the two nearly complete lateral openings at base are dimorphous, one kind elongate and the other transverse; interzooecial calcified avicularia are straight, their opening oval, with posterior portion denticulate. **Cret.–Recent.**

V. fusiforme (C and B) (**103**—25). Zoarium incrusting shells and pebbles; zooecia hexagonal, somewhat elongate, usually united to bordering ones by their mural rims. **Eoc.:** N. C., Ga., Fla., Ala. (Jackson).

FLORIDINA Jullien 1881

(**Mollia antiqua* Smitt). Zoaria incrusting or erect; opening trifoliate; avicularium opening oval. **Cret.–Recent.**

F. regularis Canu and Bassler (**103**—23). Zoarium incrusting shells and consisting of one or two superposed lamellae; zooecia hexagonal and regular. **Mioc.:** Va., N. C.

MICROPORA Gray 1848

(**Flustra coriacea* Esper). Zooecia with opesiules (lateral indentations) and avicularia, and endozooecial ovicell. **Cret.–Recent.**

***M.** (**Flustra**) **coriacea** (Esper) (**103**—26). Zooecia 0.5 to 0.6 mm long with very prominent ovicell and smooth cryptocyst. **Eoc.–Recent:** N. C. to Fla.

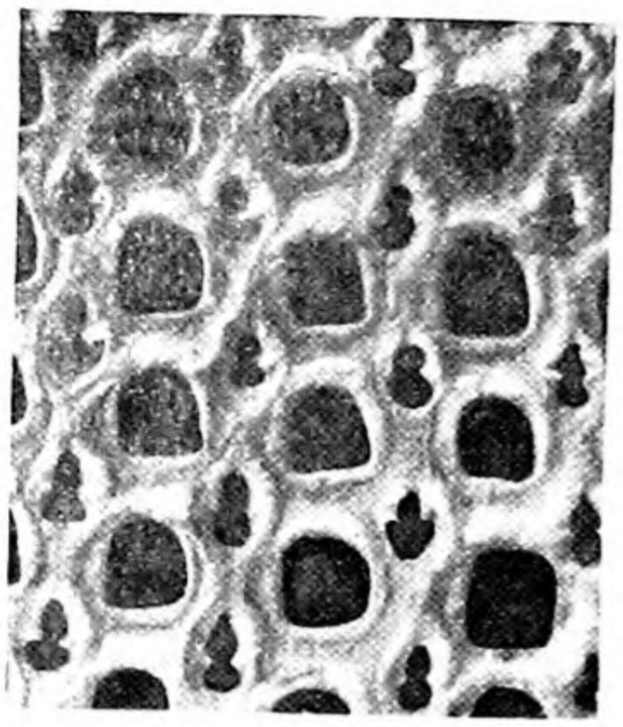
FLORIDINELLA Canu and Bassler 1917

(**F. vicksburgica*). Ovicell within zooecium and separated from proximal portion by a basal fold; convexity of zooecium not prominent; indentations

PLATE 103

[Figures are x20 and after Canu and Bassler [USNM, B 106, 125] unless otherwise indicated.]

1–3. Diamesopora dichotoma [Pal N Y 2]. Incomplete specimen (x1) and two portions somewhat enlarged to show surface. **4. Lichenalia concentrica** (x1) [Pal N Y 2]. **5, 6. Stictotrypa punctipora** [Pal N Y 2]. An incomplete zoarium (x1) and portion of surface somewhat enlarged. **7. Actinotrypa peculiaris** [Ill G S 8]. Surface (x9) showing zooecia and a macula. **8–12. Evactinopora** spp. **8–11. E. radiata** [CSNH, J 7]. Tangential and vertical sections of a ray (x18); basal and lateral views of a fragmental specimen preserving several bifoliate rays (x1). **12. E. grandis** [Ill G S 8]. A nearly complete zoarium (x1). **13. Conopeum lamellosum. 14. Trochopora bouei.** A nearly complete zoarium. **15, 16. Worthenopora spinosa** [Ill G S 8]. Portion of branch enlarged (x9, x28). **17, 18. Acanthodesia** spp. **17. A. oblongula. 18. A. savartii** forma **bifoliata. 19, 20. Periporosella (Membraniporina)** spp. **19. P. plebeia. 20. P. rimulata** [Md G S, Eoc]. **21. Paleschara incrustans** [Pal N Y 2]. A zoarium, considerably enlarged (x6), incrusting a coral. **22. Coscinopleura digitata.** A fragment (x25) showing numerous ovicelled zooecia. **23. Floridina regularis.** External layer of incrusting zoarium. **24. Discoporella umbellata** (x25). **25. Velumella fusiforme. 26. Micropora (Flustra) coriacea.**



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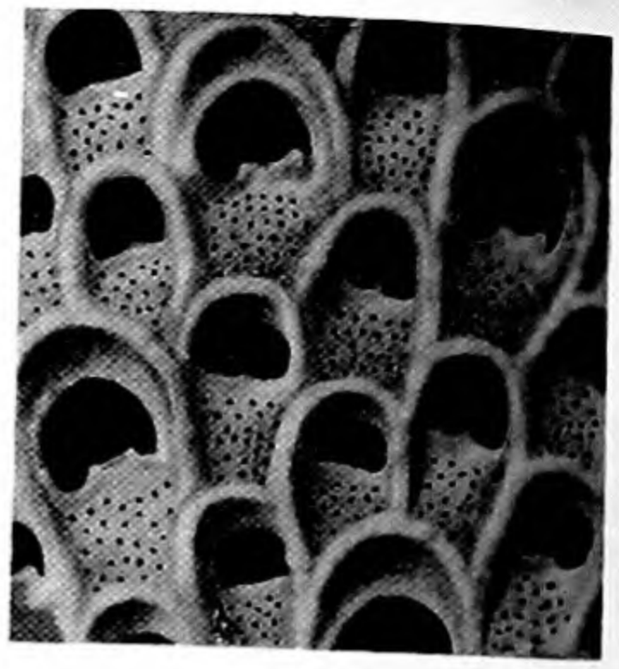

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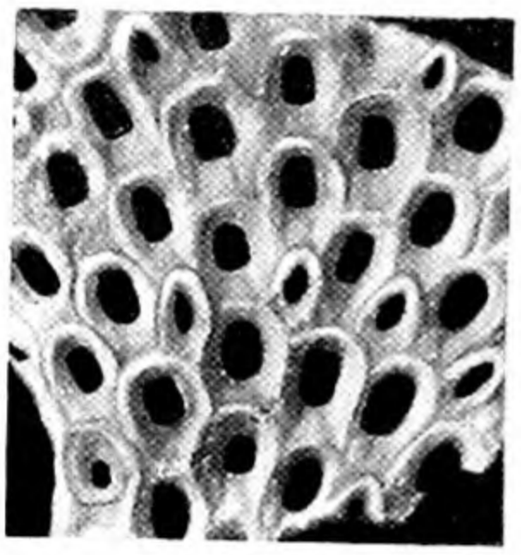

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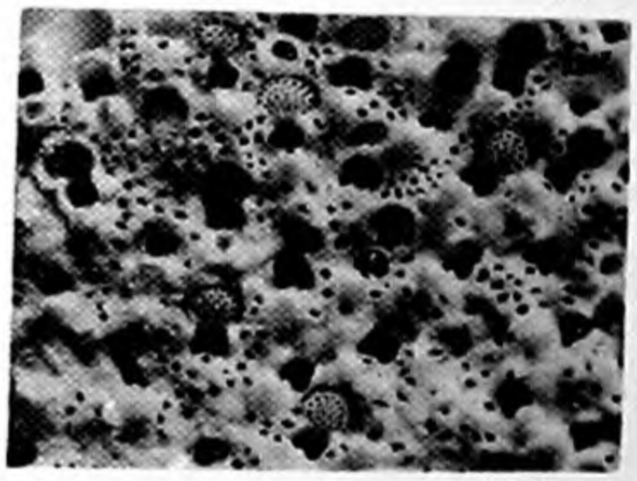

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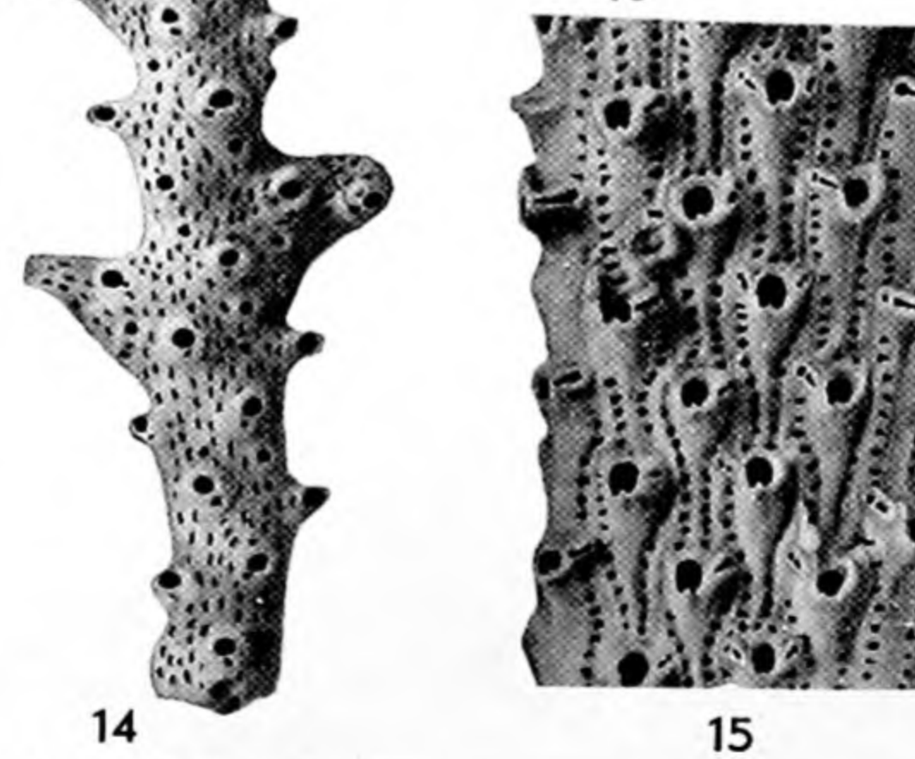

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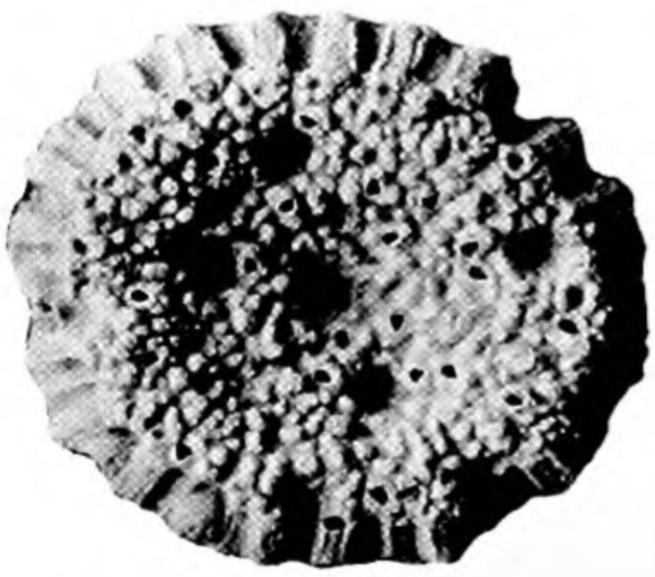

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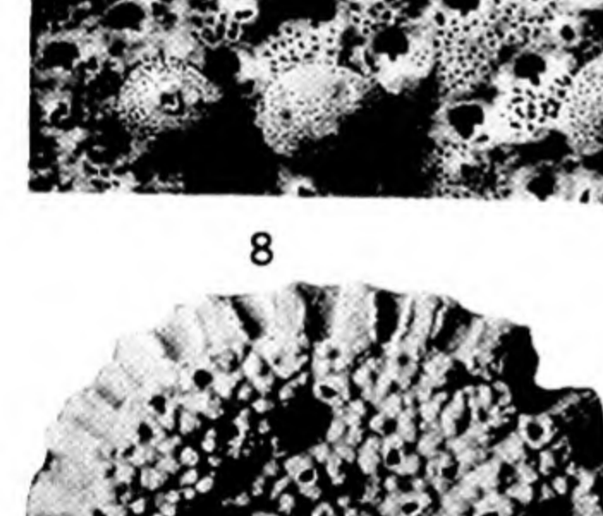

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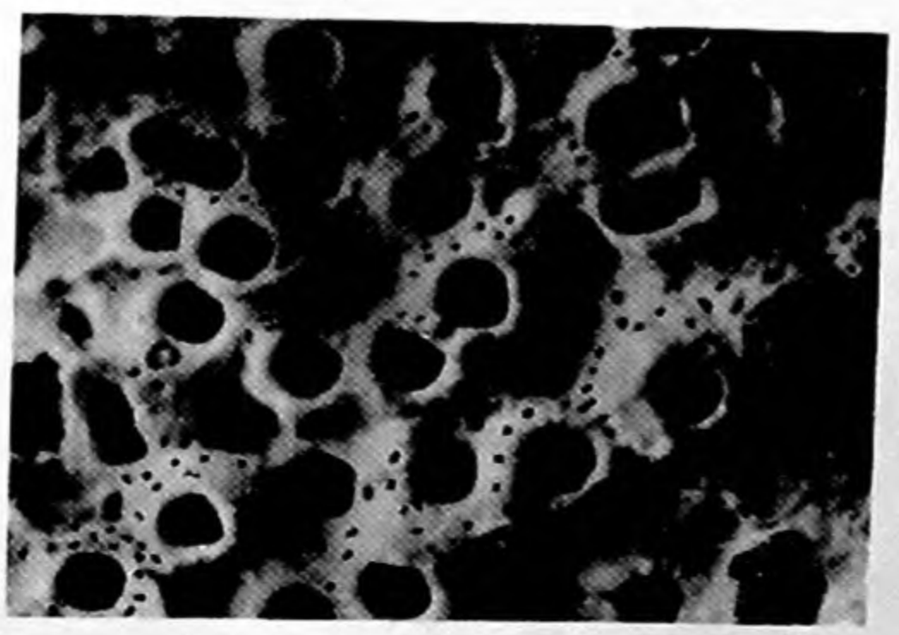

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in wall for depressor muscles large and rounded; anterior to these are two lateral teeth constricting the aperture. **Cret.–Recent.**

***F. vicksburgica** C and B (**104**—5). Zoarium a hollow cylinder with zooecia 0.50 by 0.40 mm and noncelluliferous face with tuberosities. **Olig.:** Ala. (Vicksburg).

REPTOLUNULITES Orbigny 1852

(**R. angulosa*). Zoarium a conical disk; vibracula symmetrical; both exteriorly and interiorly zooecia are arranged in radial rows; closed basal zooecia raise colony above drifting sands; ovicell within zooecium (endozooecial). **Cret.–Recent.**

R. distans (Lonsdale) (**104**—1). Zoarium large, convex, with rows of zooecia alternating with rows of vibracula; zooecia and vibracula equal in size. **Eoc., Olig.** (Jackson, Vicksburg): N. C to Ala.

R. verrucosa (Canu and Bassler) (**104**—9, 10). The basal zooecia give the zoarium a wartlike (verrucose) appearance; vibracula small and lozenge-shaped, arranged in rows. **Eoc., Olig.:** M. and U. Jackson of N. C., Ga., Fla.; Vicksburg of Ala.

STEGANOPORELLA Smitt 1873

(**Membranipora magnilabris* Busk). Zooecia with an ascending tube (polypide tube); ovicells and avicularia absent. **Eoc.–Recent.**

S. vicksburgica Canu and Bassler (**104**—6). Zoarium bifoliate with smaller zooecia bearing inconspicuous polypidian tubes, and the larger with one very prominent. **Vicksburg:** Ala.

EURITINA Canu 1900

(**Eschara eurita* Orbigny). Ovicell placed upon distal portion of zooecium, never closed by an opercular valve; avicularium interzooecial; dietellae absent. **U. Cret.–Eoc.**

E. torta (Gabb and Horn) (**104**—2). Zoarium small, bilamellar, with lamellae back to back and easily separated; cellules in longitudinal lines usually in quincunx; zooecia close together; aperture oval, about half of cell surface, without lip or peristome; zoarium increased in width by interpolation of new rows of zooecia; ovicells few. **M. Eoc.:** N. J. (Rancocas), Md. (Aquia).

CRIBRILINA Gray 1848

(**Lepralia punctata* Hassall). Zooecium closed by an opercular valve; costules generally closely consolidated; lacunae large and few in number; lumen more or less distinct; dietellae irregular in number, at least three lateral pairs; ovicell hyperstomial and always closed by an operculum. **Eoc.–Recent.**

C. verrucosa Canu and Bassler (**104**—17). Incrusts other bryozoans; the two oral avicularia without pivot. **Paleoc.** (Midway): Ga., Ala., Ark.

METRACOLPOSA Canu and Bassler 1917

(**M. robusta*). A cribriline with ovicell large and with larger aperture than other zooecia. **Eoc.**

***M. robusta** C and B (**104**—7). Zoarium free, bilamellar, with zooecia narrow and with avicularia. **M. Jacksonian:** N. C., S. C.

TREMOTOICHOS Canu and Bassler 1917

(**T. rectifurcatum*). Small, ramose, with frontal bearing zooecia with spiramen and both frontal and dorsal covered with sulci. **Eoc.**

***T. rectifurcatum** C and B (**104**—14). Zoarium branching almost at right angles with very thick dorsal and indistinct zooecia on the frontal. **Jacksonian:** N. C. to Fla.

STYLOPOMA Levinsen 1909

(**Eschara spongites* (?Pallas) Levinsen). Zoarium variable; zooecia with frontal calcified; orifice ranging from semicircular to suborbicular, with a distinct notch in lower margin; ovicell hyperstomial, covering aperture and avicularia entirely. **Mioc.–Recent.**

***S. spongites** Pallas (= **Schizoporella informata** Lonsdale) (**104**—8). Irregular botryoidal or nodulose masses of superposed layers of zooecia, 20 to 40 mm in diameter; cells with terminal subcircular aperture having distinct peristome and deep and sharp proximal notch; entire surface punctate; avicularia uncommon. **Mioc.:** Va., N. C., S. C.; **Plioc.:** Fla.; Panama; **Recent:** Coasts of Fla. and Bermuda.

TUBUCELLARIA Orbigny 1852

(**Cellaria cereoides* Ellis and Solander). Articulated zoaria composed of zooecia with a peristomial ovicell and a frontal with an ascopore and long tubules. **Eoc.–Recent.**

T. vicksburgica Canu and Bassler (**104**—3, 4). Segments long and large with distinct swollen zooecia covered with large polygonal pores. **Vicksburg:** Ala.

PORELLA Gray 1848

(**Millepora compressa* Sowerby). Zoaria incrusting or erect; walls porous; aperture of zooecium somewhat produced, roughly crescent-shaped, within the horns of which is an avicularium. **Eoc.–Recent.**

PLATE 104

[Figures are x20 and after Canu and Bassler [USNM, B 106, 125] unless otherwise indicated.]

1. Reptolunulites distans. Normal zooecia and well developed vibracula. **2. Euritina torta. 3, 4. Tubucellaria vicksburgica.** A highly magnified stem and a nearly complete zoarium (x1). **5. Floridinella vicksburgica.** A small zoarium (x25) showing its unilaminar, hollow cylindrical form. **6. Steganoporella vicksburgica. 7. Metracolposa robusta.** Surface showing ovicelled zooecia. **8. Stylopoma spongites.** Normal and ovicelled zooecia. **9, 10. Reptolunulites verrucosa.** Zoarium (x1); surface showing thick hydrostatic zooecia. **11. Porella jacksonica.** Zoarium with striated, indistinct zooecia. **12, 13. Mamillopora tuberosa.** Inner surface of zoarium (x10). **14. Tremotoichos rectifurcatum. 15. Trigonopora moniliferum. 16. Holoporella orbifera. 17. Cribrilina verrucosa.** Zoarium showing well developed lacunae. **18. Adeona heckeli** (x16) [Md G S, Mioc].

P. jacksonica Canu and Bassler (**104**—11). Zoarium formed of two lamellae back to back: fronds flat or undulating; zooecia elongate fusiform, the part in front of aperture convex and bearing a huge avicularium. **Eoc.** (Jackson): N. C. to Fla., Miss.

TRIGONOPORA Maplestone 1902
(= METRARABDOTOS Canu 1914)

(**T. vermicularis*). Ovicell within zooecium; aperture semilunar with an indentation (rimule) and median tooth (lyrula). **Eoc.–Recent.**

T. moniliferum Milne-Edwards (**104**—15). Zoarium bifoliate, ramose, with orifice of ovicelled zooecia (0.3 mm) three times larger than the ordinary ones. **Vicksburg:** Ala., Miss.; **U. Eoc.–Plioc.** of Europe.

ADEONA Lamouroux 1812

(**A. grisea*). Incrusting, with bulbous or flat cells having subcircular to semicircular opening, beneath which is a second circular or crescentic pore (an ascopore opening into the compensatrix); operculum semilunar; gonoecia distinct, larger than ordinary zooecia. **Tert.–Recent.**

A. heckeli Reuss (= **Adeonellopsis umbilicata** Lonsdale) (**104**—18). Irregular nodose masses of numerous layers; zooecia irregular, the outline of each marked by a row of pores; upper front wall coarsely punctate; aperture anterior, semielliptical; two smaller apertures on proximal portion of cell. **L. Mioc.:** Va., N. C.; Jamaica; **Plioc.:** Fla.

HOLOPORELLA Waters 1909

(**Cellepora descostilsii* Savigny-Audouin). Zoarium free or incrusting; lower lip of aperture more or less straight; ovicell a widely opened cup; both oral and interzooecial avicularia usually present. **Eoc.–Recent.**

H. orbifera Canu and Bassler (**104**—16). Zoarium usually forming branched masses 2 cm long; zooecia barely distinct, erect; aperture large, orbicular, with a concave proximal border; the slope in all directions outward from aperture is smooth and bounded by pores; oral avicularia rare, interzooecial ones large and elliptical. **Mioc.–Plioc.:** N. C. to Fla.

MAMILLOPORA Smitt 1873

(**M. cupula*). Zoarium cupuliform, openings elliptical, with two submedian hinge projections; zooecia with their inner sides covered by hollow tuberosities; zoarium unilaminar, showing position of zooecia on under surface. **Eoc.–Recent.**

M. tuberosa Canu and Bassler (**104**—12, 13). Zoarium free, with very thick walls; characterized by peristominal tuberosities. **L. Mioc.:** Costa Rica (Gatun); Santo Domingo; Jamaica.

CHAPTER IX

PHYLUM BRACHIOPODA[1,2]

PREPARED BY G. ARTHUR COOPER, ASSOCIATE CURATOR, U. S. NATIONAL MUSEUM

INTRODUCTION

Definition. Brachiopods are bilaterally symmetrical, inequivalved marine bivalves having shells composed of chitino-phosphatic or calcareous material. They are pediculate or sessile; the attached valve is always *ventral*; the opposite valve, *dorsal*. Pediculate brachiopods are fastened by a fleshy or cartilaginous pedicle that protrudes from an opening in the beak of the ventral valve (often called *pedicle valve*). Sessile brachiopods are cemented by the ventral beak or umbo to some object such as a shell, coral, or rock. A few pediculate forms with muscular fleshy pedicle have the ability to burrow in sand and mud and to move about slowly. The valves are held together by teeth and sockets in *articulate* brachiopods, but by muscles only in *inarticulate* brachiopods.

Orientation and Form. In orienting a brachiopod the pedicle or beak end is *posterior* and the opposite margin *anterior*. The valves are articulated at the posterior and the line of articulation is known as the *hinge*. This may be narrow or produced laterally to form a *cardinal line* or *hinge line* (**134**—3). The lateral extremities of the hinge are the *cardinal extremities* and may be rounded, obtuse, acutely angular, or produced into ears (*alate*) (**132**—23) or into points (*mucronate*) (**122**—5, 6). The line of shell juncture is the *commissure* (*lateral* and *anterior commissure* (**105**—3; **113**—16)). The anterior commissure is *sulcate* (**143**—50, 51) if it is bent more or less sharply in a ventral direction; *uniplicate* (**113**—16) if folded in a dorsal direction.

The *length* (**105**—1, 3) of a brachiopod is the distance from the beak to the midpoint of the

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[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] The following references are almost entirely to reports in which large numbers of brachiopods are listed, described, and figured. Any adequate list of short papers would have been much too long for the present purpose. The more important references, however, are included in the bibliographies of the reports here listed.

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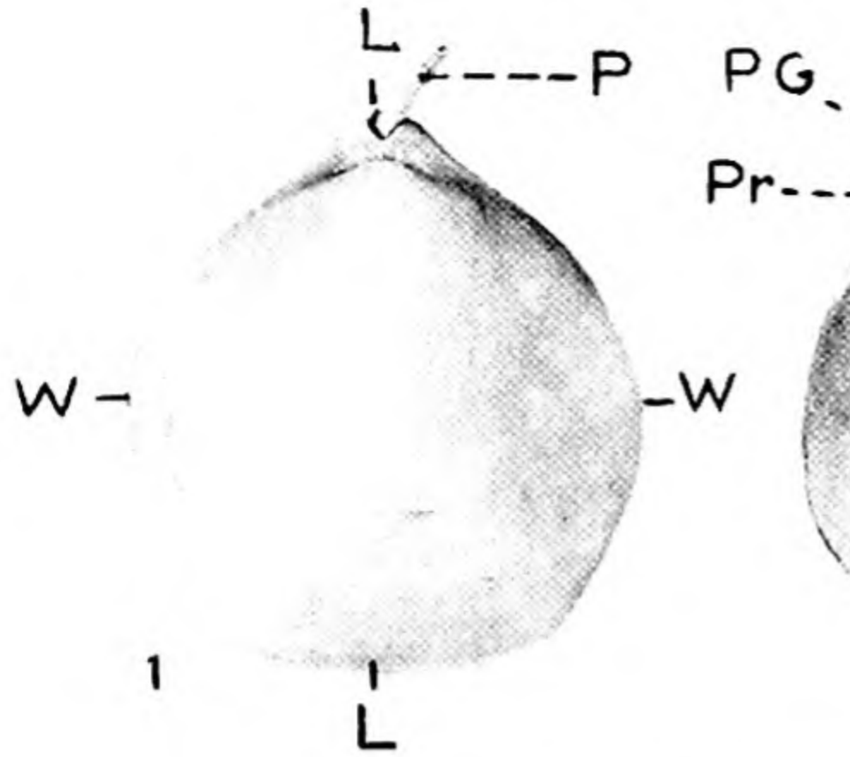

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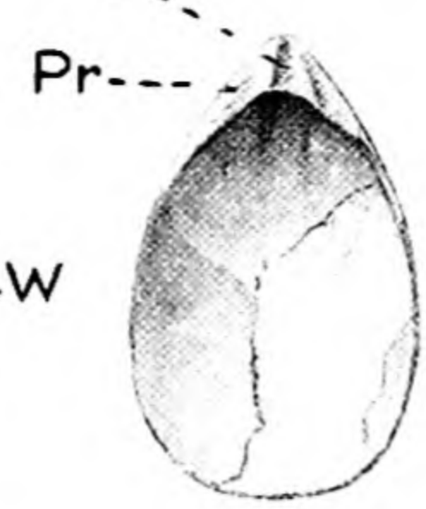

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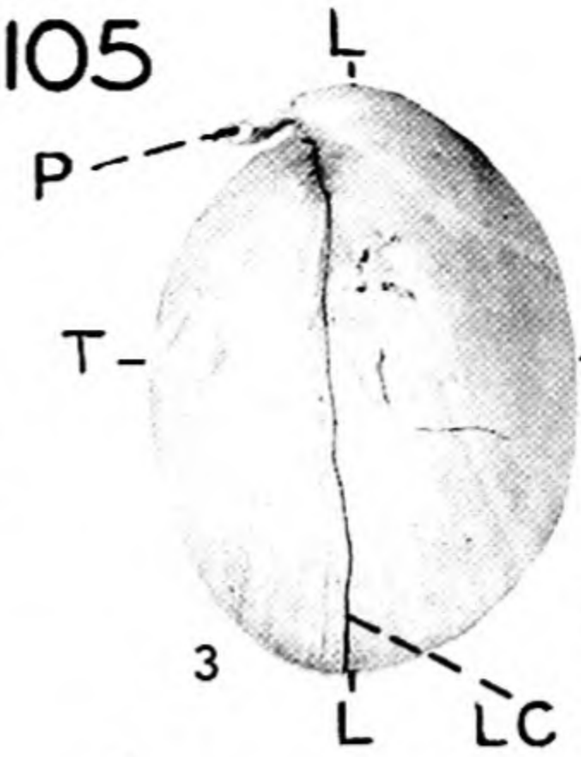

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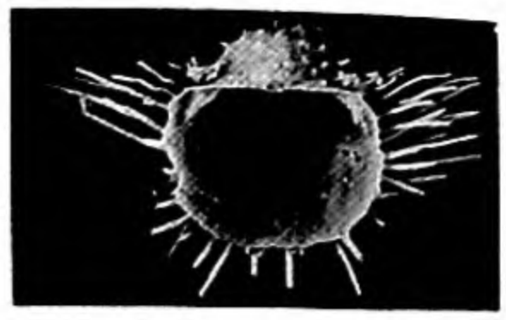

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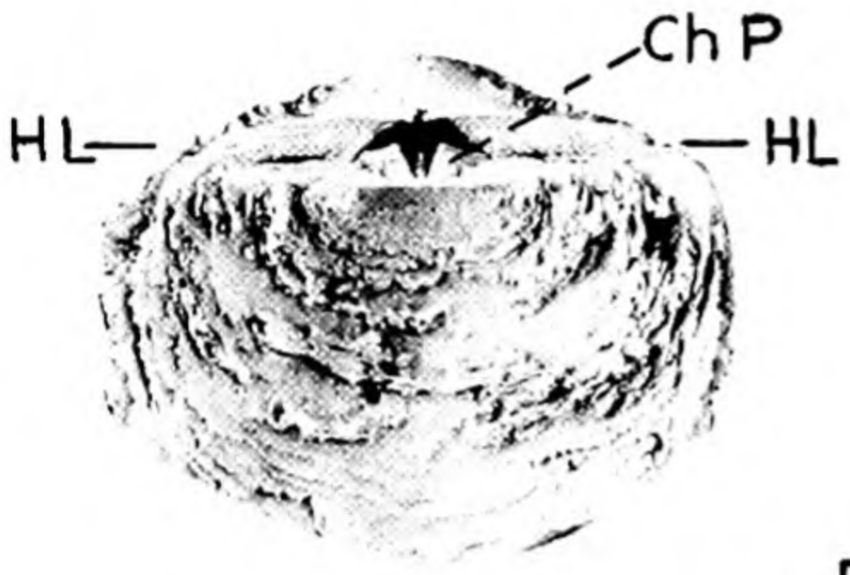

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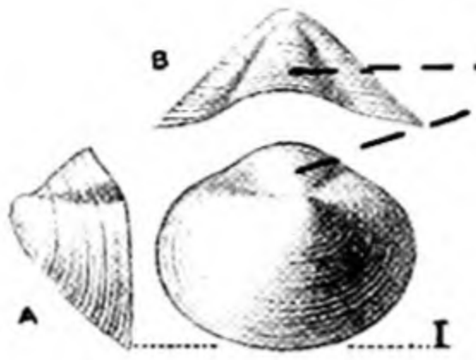

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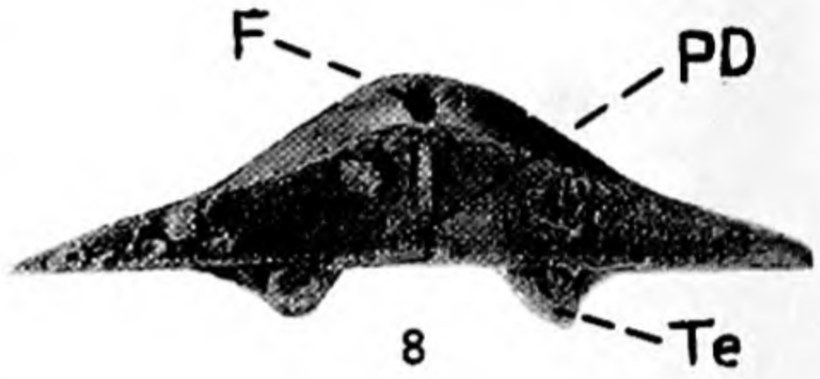

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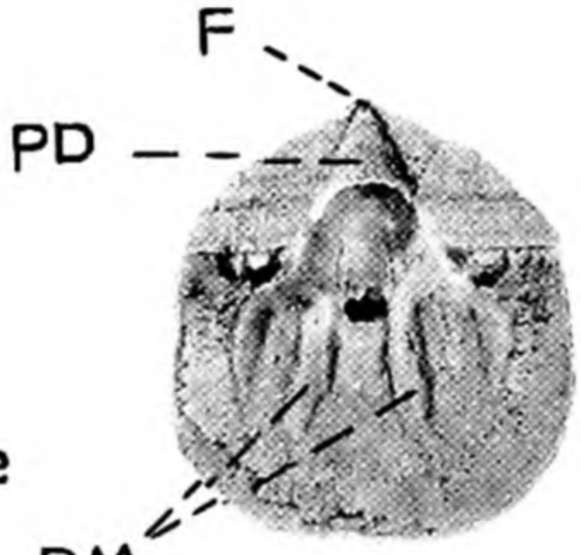

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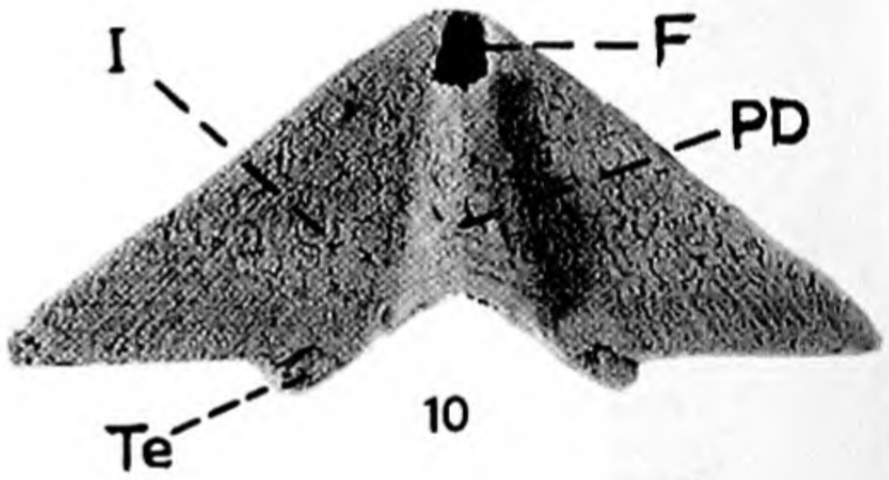

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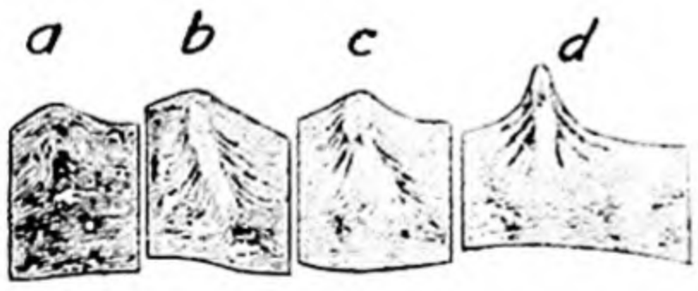

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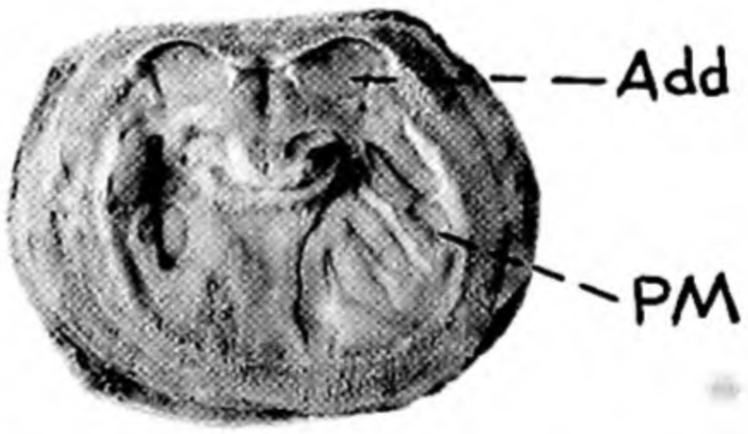

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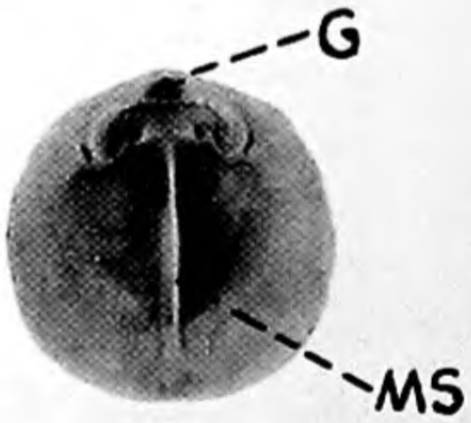

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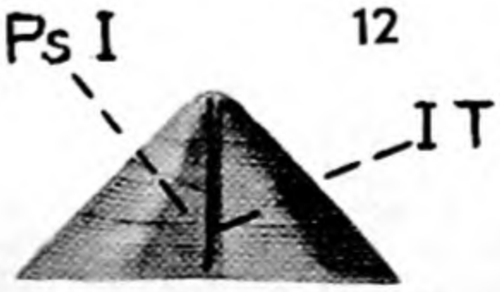

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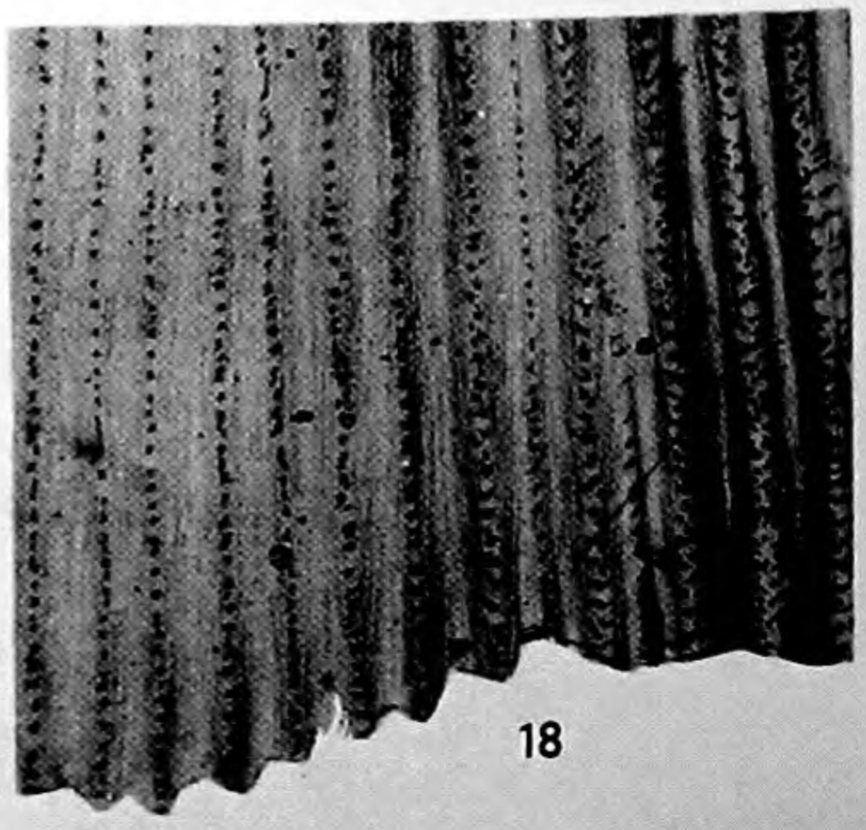

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anterior margin; *surface length* may be used in comparing strongly geniculated brachiopods and is measured on the surface between the beak and the midpoint of the anterior margin. *Width* (**105**—1) is taken at the widest part at right angles to the length. In describing brachiopods it is good practice to cite the position of maximum width and in narrow-hinged forms to state the hinge width as well as the maximum width. *Thickness* (**105**—3) is measured along the greatest distance between the ventral and dorsal valves. It is desirable to cite the position of maximum thickness in a brachiopod description.

When describing and figuring a brachiopod it is customary to orient the specimen with the ventral valve down and the posterior end away from the observer. To avoid ambiguity, directions along the line of thickness are spoken of as ventral and dorsal; directions along the length are posterior and anterior. Such ambiguous expressions as "up" and "down" should be avoided.

The animal. Inside the valves the animal occupies two cavities separated by a *body wall*. The smaller and posterior cavity is the *coelome* or *visceral cavity* and contains the U-shaped digestive canal, muscles, sex glands, and liver. The digestive canal consists of an esophagus, stomach, and intestine. The stomach is surrounded by a large digestive gland or liver. The entire coelome and its extensions into the mantle are filled by a fluid or blood.

The anterior cavity situated between the mantle lobes is known as the *mantle* or *brachial cavity*. Here is lodged the *lophophore* (or *brachia*) which surrounds the mouth. The lophophore is a more or less complicated, cirrate loop used to create food-bearing currents when the valves are agape and filled with sea-water. The mantle, which is a thin membrane lining the inside of the cavity, secretes the shell. Extensions of the coelome or *pallial sinuses* (**106**—1) ramify throughout the mantle in patterns characteristic of major divisions of brachiopods.

Brachiopods are dioecious, the animal having four genital glands, two on each side of the body. In some genera the glands are confined to the visceral cavity but in others their extensions occupy the main trunks of the pallial sinuses. The genital products are discharged into the visceral cavity and reach the mantle cavity through small trumpet-shaped nephridia lodged in the body-wall. Many of the soft body parts such as the muscles, sex glands, and pallial sinuses leave on the inside of the shell impressions which are important in defining families and genera.

Musculature. The brachiopod shell is opened by a more or less complicated set of muscles, which, in the hinged brachiopods, consist of *adductors* or closing muscles, *diductors* or opening muscles, and *adjustor* or pedicle muscles for adjusting the animal on its pedicle. The adductors extend nearly perpendicular to the plane of the valves and in the ventral valve leave two small scars. In passing from the ventral to the dorsal valve they bifurcate and produce four scars on the middle of the dorsal valve. The central position of the adductors facilitates the closing of the valves.

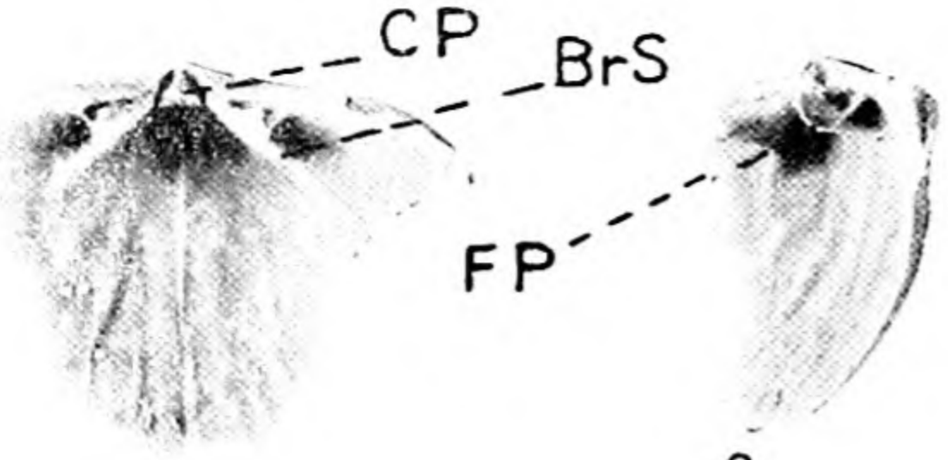
PLATE 105

[All figures are x1 and original by Cooper unless otherwise indicated. Original figures are of specimens in the U. S. National Museum.]

The following abbreviations and symbols will be used in the captions describing the figures on this and the following 38 plates of brachiopods:

Add	Adductor scars	DlP	Dental plates	LC	Lateral commissure	Se	Septum
Adj	Adjustor scars	DP	Deltidial plate	MS	Median septum	Sh	Shaft
Ant	Anterior	Dv	Dorsal valve	My	Myophore	SL	Surface length
Br	Brachiophore	Ext	Exterior, (s)	N	Notothyrium	So	Socket
BrS	Brachiophore supports	F	Foramen	OI	Ovarian impression	Sp	Spondylium
Ch	Chilidium	FP	Fulcral plate	P	Pedicle	SPA	Scar of pedicle attachment
CHP	Concave hinge-plate	G	Groove	Pa	Palintrope	SR	Socket ridge
CP	Cardinal process	HL	Hinge line	PD	Pseudodeltidium	T	Thickness
ChP	Chilidial plates	Ho	Homeodeltidium	PG	Pedicle groove	Te	Teeth
Cr	Crura	HP	Hinge plate	PM	Pallial marking	V	Ventral
D	Dorsal	I	Interarea	Post	Posterior	V ext	Ventral exterior
De	Delthyrium	Int	Interior, (s)	Pr	Proparea	V int	Ventral interior
D ext	Dorsal exterior	Int F	Internal filling	PS	Pallial sinus	VM	Vascula media
DHP	Divided hinge-plate	IT	Inter-Trough	PsI	Pseudointerarea	Vv	Ventral valve
Di	Diductor scars	J	Jugum	PSp	Pseudospondylium	W	Width
D int	Dorsal interior	L	Length	S	Side		

1. Laqueus. D view showing length, width, and pedicle. **2. Linguella** (x3.5) [USGS, M 51]. V int showing propareas and pedicle groove. **3. Laqueus.** S view showing length, thickness, lateral commissure, and pedicle of a modern shell. **4. Avonia.** Vv showing long spines. **5. Hesperorthis** (x2). Post view showing interarea and delthyrium partly restricted by a short pseudodeltidium and lateral plates which resemble deltidial plates. **6. Bimuria** (x2). D view showing both interareas, delthyrium, and notothyrium partly covered by chilidial plates. **7. Paterina** [USGS, M 51]. Three views of a Vv showing homoeodeltidium. **8. Oxoplecia** (x3). Post view showing interareas, tooth, flat pseudodeltidium, and apical foramen. **9. Billingsella** (x2). V int showing pallial impressions, minute foramen, delthyrial cavity, and strongly arched pseudodeltidium. **10. Tritoechia** (x3). Post view showing interarea, foramen, teeth, and strongly arched pseudodeltidium. **11. Campages** (x4), a modern brachiopod. Vv showing fused deltidial plates, large pedicle opening (foramen), and tooth. **12. Crania** (x2), a modern brachiopod. V int showing pallial markings and adductor scars. **13. Conotreta** (x10). D int showing high median septum, median groove, and muscle scars. **14, 15.** Diagrams illustrating pseudopunctae (x40) [Pal Polonica 1]. **16, 17. "Acrotreta."** Post and apical views showing pseudointerarea and longitudinal furrow or intertrough. **18. Pionodema** (x40). Longitudinal section showing endopunctae [original by L. G. Henbest].



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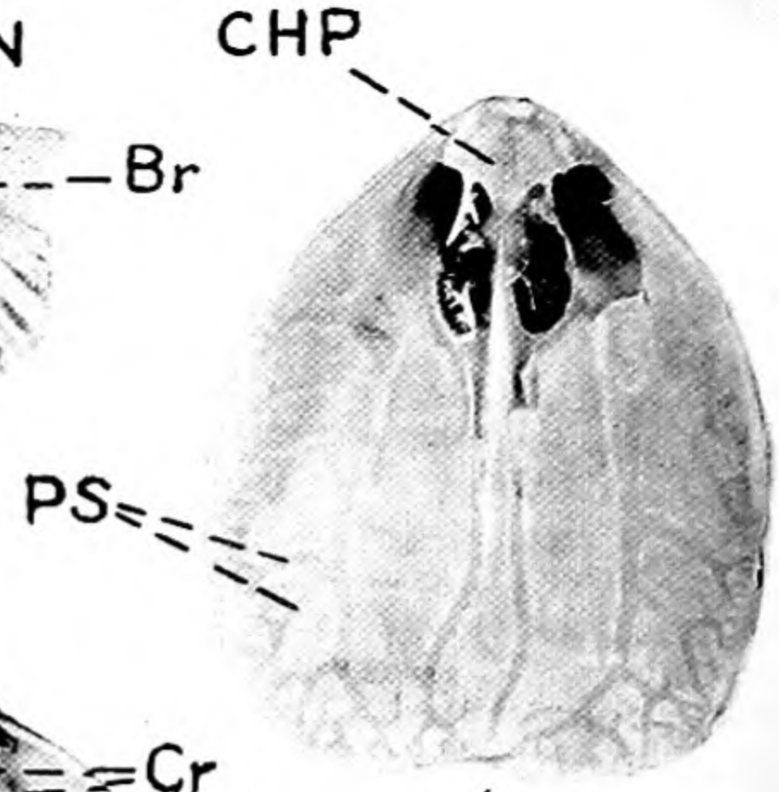

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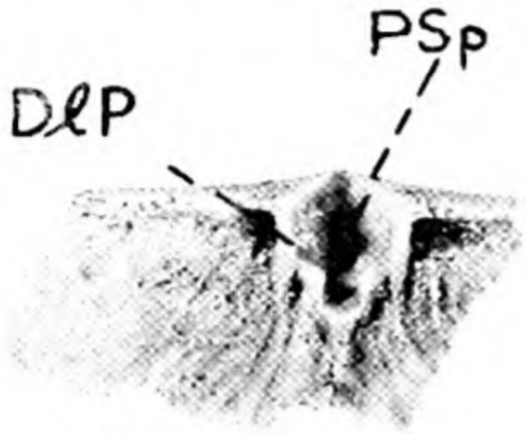

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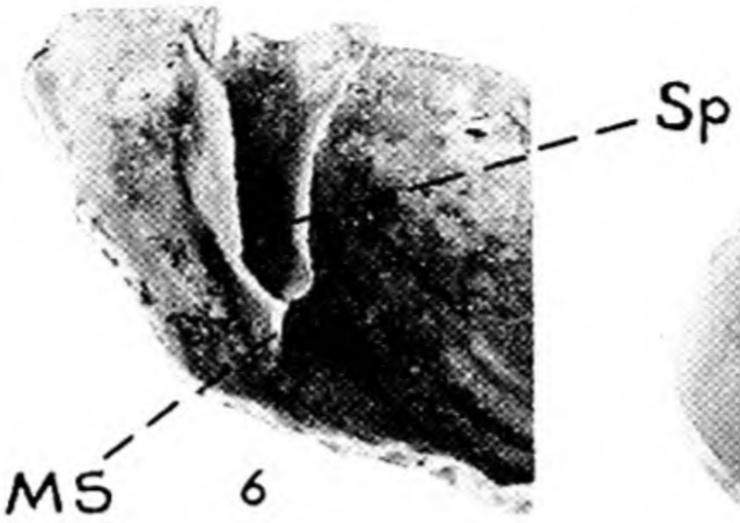

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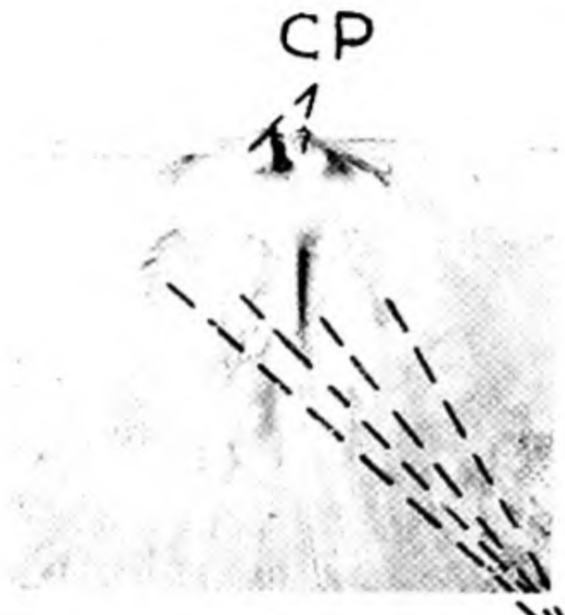

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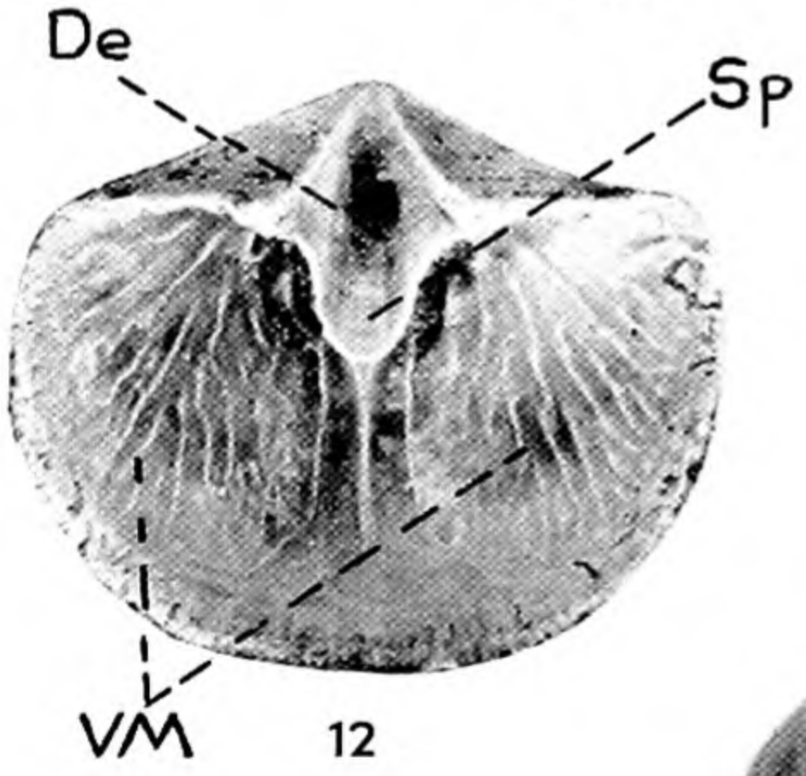

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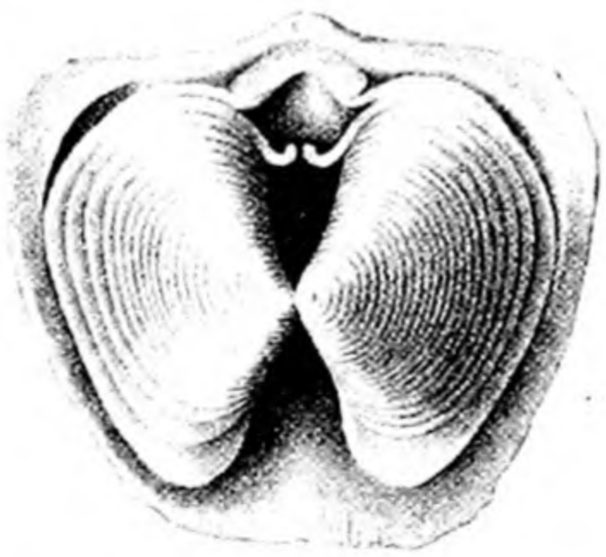

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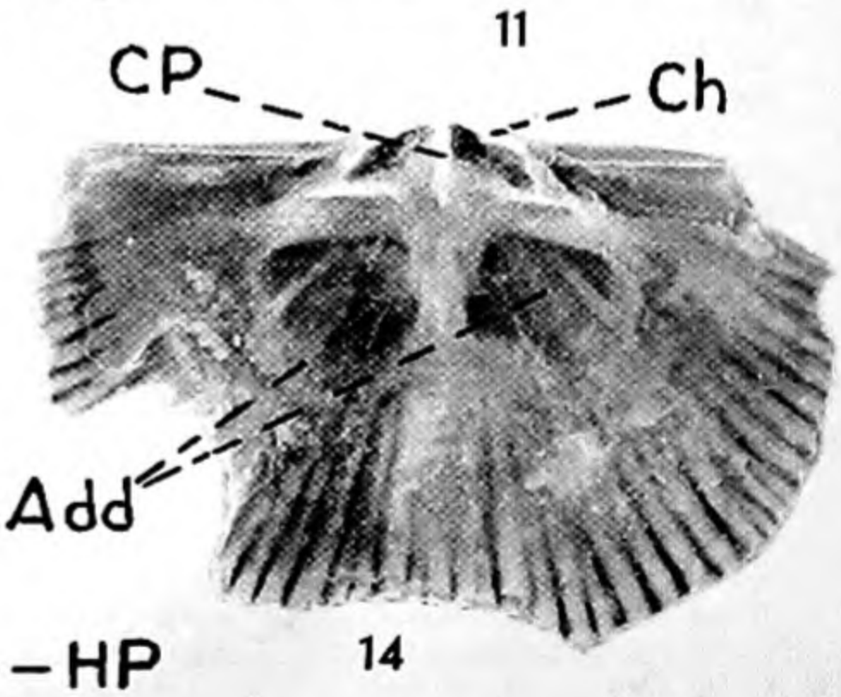

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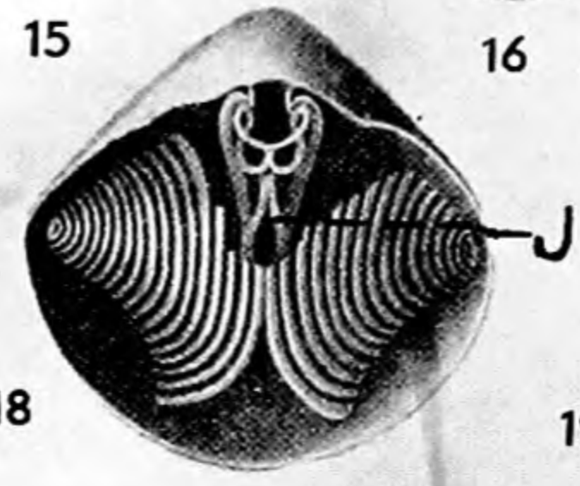

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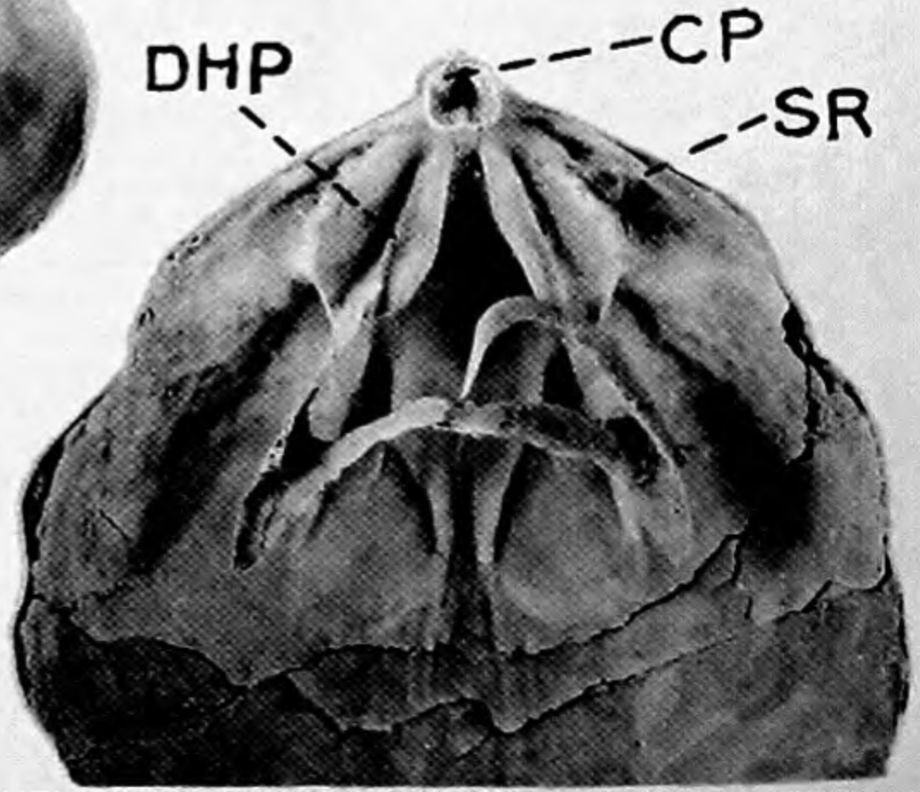

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The diductor muscles form large flabellate or elongate scars on each side of the adductor scars in the ventral umbonal region and are attached under the beak of the dorsal valve in a pit or to a more or less complicated cardinal process (**106**). Contraction of the diductors pulls the dorsal beak in a ventral direction, rotates the valve on the ventral teeth, and simultaneously stretches the adductors. Relaxation of all the muscles causes the valves to close. A pair of *accessory diductors* is often present posterior to the adductor scars in the ventral valve but are seldom seen in Paleozoic brachiopods. The adjustor muscles attach the pedicle to the shell and allow the pedicle to be retracted. The adjustor scars are generally located on the outside of the diductor scars in the ventral valve. An *unpaired pedicle muscle* is present in many Mesozoic to Recent brachiopods and leaves a crescentic scar posterior to the accessory diductors.

Shell Composition and Structure. Two great groups of brachiopods based on shell structure are recognized: (1) chitinous or chitino-phosphatic brachiopods; and (2) calcareous brachiopods.

(1) Some brachiopods have a shell composed of chitin only but in others such as *Discinisca* calcium phosphate is distributed uniformly through the chitinous material. In *Lingula*, on the other hand, layers of chitinous material alternate with layers of calcium phosphate. The chitinous and chitino-phosphatic shells are generally of lustrous brownish or black color and easily distinguished from the light colored calcareous brachiopods.

(2) Calcareous shells are composed of three layers of shell substance: (*a*) a thin periostracum of organic material never seen in fossils but assumed to have been present because of its universal occurrence in Recent species; (*b*) a thin outer *lamellar layer*, growing only at the shell edges, which determines the outline, plications, and other radial ornament; and (*c*) a thicker inner layer (*prismatic layer*) composed of calcareous prisms arranged obliquely to the plane of the lamellar layer. This third layer, deposited by the mantle proper, thickens the shells, obliterating plications and other internal inequalities and often burying apical and cardinal structures. Calcareous shells are divisible into three groups now recognized to have considerable taxonomic importance:

A. Punctate brachiopods. The inner fibrous layer is perforated by small holes representing cavities occupied by minute caeca of the mantle. Examples: *Pionodema, Cranaena, Rhynchospirina.*

B. Impunctate brachiopods. By far the most numerous and having the fibrous layer dense and imperforate. Examples: *Hebertella, Camarotoechia.*

C. Pseudopunctate brachiopods. The fibrous layer surrounds and often covers internal calcareous spicules. In worn or exfoliated specimens shell layers tear away from the spicules and leave coarse pits that simulate punctae. Examples: *Rafinesquina, Chonetes, Juresania.*

Calcareous brachiopods are usually articulated (*Articulata*) but the chitinous or chitino-phosphatic genera are inarticulate or have rudimentary teeth and sockets only (*Inarticulata*).

INARTICULATA

Morphology. Generally speaking the inarticulate brachiopods form a conservative group which had its heyday in the early Paleozoic and is now represented by only a few persistent types. Most inarticulates are pediculate but one family, the Craniidae, is composed of sessile types and is exceptional also in having calcareous shells. Simplicity of form is a prime inarticulate character. Most shells are circular or nearly so in outline and conical in profile, but some are linguiform in outline and compressed lenticular in profile. The conical forms, except for the attached Craniidae, are fixed by short pedicles. The lingulids, on the other hand, have a long fleshy pedicle and live in agglutinated burrows with their front, setiferous margin protruding.

The pedicle is variously attached. In the lingulids it is attached near the apex of the ventral valve but in the conical forms it emerges through a small circular or oval foramen. Classification of these forms is based on the nature and position of the foramen.

The muscle system is more complicated than that of the Articulata because the valves are lifted or slid laterally rather than rotated on teeth. The *palintrope*, like that of the Articulata, is a shelf growing anterodorsally. The smooth somewhat triangular areas on each side of the delthyrium and notothyrium are known as *propareas* (**105**—2). The *homoeodeltidium* (**105**—7) is a convex, arched, median part of the palintrope of a few genera such as *Paterina*. This structure has been homologized with the pseudodeltidium. The *pseudointerarea* (**105**—16, 17) of many inarticulate genera such as *Prototreta* is characterized by a narrow, longitudinal median depression

PLATE 106

[All figures are x1 and original by Cooper unless otherwise indicated.]

1, 2. Schizophoria (x2). D int viewed ventrally and from side, showing cardinal process, brachiophore supports, and fulcral plate. **3. Hesperorthis** (x2). D int showing notothyrial cavity and long brachiophores. **4. Dallina** (x2), a modern shell showing concave hinge plate and pallial sinuses. **5. Apheoorthis** (x3). Apical portion of V int showing dental plates and pseudospondylium. **6, 11. Anastrophia** (x3). V int showing spondylium in lateral and dorsal views. **7. "Hemithyris,"** a modern shell, D int showing crura and pallial markings. **8. Plaesiomys** (x2). Ventral muscular area showing parts. **9. Rafinesquina.** Post portion of D int showing adductor scars and bilobed cardinal process. **10. Heterorthina** (x4). Post portion of D int showing lobate cardinal process and brachiophores. **11.** See 6 above. **12. Ladogiella** (x3). V int showing palintrope, spondylium, pallial trunks, and ovarian impressions. **13. Atrypa** [Pal N Y 8 (2)]. Dorsally coiled spires. **14. Vellamo trentonensis** (x3). V int showing chilidium, cardinal process, and adductor scars. **15. Terebratulina,** a modern shell, showing a short loop. **16. Terebratella,** a modern shell, showing a complicated loop attached to a median septum. **17. Campylorthis** (x1.5). V int showing muscular area, pallial marks, and ovarian impressions. **18. Meristella** [Pal N Y 8 (2)]. Spiralia and jugum. **19. Terebratula.** D int showing divided hinge plate and loop.

of uncertain origin called the *intertrough* (**105**—16, 17). The *listrium* is a shelly plate restricting the long slitlike pedicle opening of certain inarticulates such as *Orbiculoidea*.

ARTICULATA

Outline and Profile. Articulate brachiopods possess a variety of forms, ranging from nearly circular to elongate, with length greater than width, and transverse, with width greater than length. The profile is also quite variable. In referring to the *lateral profile* of a brachiopod established convention requires mention of the dorsal valve first. Thus a shell such as *Stropheodonta* is *concavo-convex* because the dorsal valve is concave; *Dinorthis is convexi-concave* because the dorsal valve is convex and ventral concave. Biconvex brachiopods are called *lenticular*. A few brachiopods, such as *Strophomena*, are said to be *resupinate* when the profile in youth is concavo-convex but reversed to convexi-concave in maturity.

Ornamentation (105, 106). The surface of a brachiopod shell may be smooth or it may be ornamented by radial or concentric lines, folds, lamellae, or spines. Radial ornamentation consists of *costae* when strong (*Hesperorthis*) and *costellae* when fine (*Enteletes*). A *plication* or *fold* is a major undulation of the shell. Most brachiopods develop a *median fold* on one of the valves, usually the dorsal one, that may facilitate passage of food-bearing water currents.

Most brachiopods are marked by concentric lines of growth, but more pronounced concentric ornamentation may take the form of fine elevated lines or *fila* (*Oxoplecia*), stronger *lamellae* (*Glyptorthis*), or strong undulations called *rugae* (*Leptaena*). Lamellae are often extravagantly extended into *frills* as in *Atrypa*. Where fila undulate over costellae, or lamellae make contact with costae, spines may form (*Atrypa*). In a few genera, such as *Platystrophia* and *Spinocyrtia*, the entire surface is covered by fine *papillae*. Hollow spines are common on many spiriferoid genera such as *Elytha* and *Nucleospira*. In the chonetids the spines are confined to the ventral posterior margin, but in the productids long spines may occur on the surface of one or both valves; those of the cardinal extremities often have great length. Ornamentation is of great value in separating species and often in distinguishing genera.

Interior Features. Since the major generic and family characters are found inside the brachiopod shell, no pains should be spared in preparing and determining the interior structures.

Structures of the ventral (pedicle) valve **(105, 106).** As the brachiopod is attached by the pedicle or by the ventral valve itself, this valve generally is more modified than the dorsal, which serves as a lid. Besides the pedicle, the ventral valve is characterized by the *delthyrium*, a triangular notch located under the beak and in the middle of a flat shelf (the *palintrope*) growing anterodorsally from the posterior margin. The outer surface of the palintrope is the *interarea* and the anterior edge of the palintrope is the *hinge margin*.

The delthyrium is partly or completely closed by one of the following types of cover: (1) *Deltidial plates* consisting of two discrete pieces which grow laterally and anteriorly from the delthyrial edges. These are present in some Protremata but are not common except in the rhynchonellids and terebratulids. (2) The *pseudodeltidium*, a single flat or convex plate, with or without an apical perforation, growing from the apex and usually covering most of the delthyrium. This characterizes orthids, clitambonitids, strophomenids, streptorhynchids, plectambonitids, chonetids, and some spiriferids.

The articulating apparatus and shell plates are attached to the palintrope. The *hinge teeth* are located at the anterior angles of the delthyrium and are often buttressed by ventral *dental plates* that bound the *delthyrial cavity* and are attached along the delthyrial edge from teeth to apex. The delthyrial cavity and the region immediately anterior to it constitute the seat of attachment of the ventral muscles and pedicle. The adjustors are located at the base of the dental plates; the diductors inside the adjustors are large and surround the small adductor scars. In many genera the adductors are attached to a more or less strong median septum (*Enteletes*).

The delthyrial cavity is often modified by obsolescence or a variation in the nature of the dental plates. The dental plates are rarely obsolete but in some Paleozoic genera they meet on the floor of the valve to form a rostral chamber designated the *sessile spondylium*. If this chamber is supported by a simple median septum, it is known as a *spondylium simplex* (*Vellamo*); if by two parallel plates, it is called a *spondylium duplex* (*Pentamerus*). In some genera a callosity develops under the muscular field in the delthyrial cavity. This simulates a spondylium and is known as a *pseudospondylium*.

In addition to muscle scars, impressions of the fleshy parts on the interior take the form of more or less sinuous tracks or low ridges representing a pattern of the pallial sinuses. Two major trunks, the *vascula media*, have their beginning at the anterior ends of the diductors and branch anteriorly. On the outer side of the dental plates are more or less reniform areas marked by oblique ridges. These are the *ovarian impressions* (*Glyptorthis*) which are the seat of attachment of the ovarian bodies.

Structures of the dorsal (brachial) valve **(106).** This is the conservative valve and is never used for attachment. The dorsal palintrope is seldom as well developed as the ventral, and in many brachiopods is obsolete. The triangular notch of the dorsal valve is the *notothyrium* and is often more or less completely covered by a *chilidium* (*Vellamo*), or by *chilidial plates* (*Pomatotrema*) which lie on the notothyrial margin.

The interior dorsal structures centering about the beak are known as the *cardinalia* and consist of the lophophore or brachial supports, the hinge plate, and the diductor muscle attachment or cardinal process.

The supports of the lophophore are of three kinds: brachiophore, crura, and brachidium. The *brachiophore* is a simple, stout and generally short,

rodlike process located on the edge of the notothyrium and overlaid by the edge of the palintrope. This structure is thought to correspond to the crural base of the hinge plate of more advanced brachiopods. Rarely a delicate process extends from the brachiophore. *Crura* (singular *crus*) are long slender generally curved processes with or without terminal hooks, attached to a *crural base* or *socket plate*. The *brachidium* or calcareous skeleton of the lophophore consists of two types, loops and spires. The *loop*, generally confined to the terebratulids, consists of a simple form having *descending lamellae* joined by a *transverse ribbon* (*Oleneothyris*) or ring (*Terebratulina*) (**106**—15) and a more complicated form having long descending lamellae and a recurved band. This latter type may be attached to the median septum as in *Terebratella* (**106**—16), or free as in *Coptothyris* or *Magellania*. The spire has descending lamellae supporting a calcareous coil directed laterally (*Platyrachella*), medially (*Zygospira*), or dorsally (*Atrypa*). The descending lamellae of the spiriferids may be united by a more or less complicated transverse band, the *jugum*.

The hinge plate is a flat or concave plate or group of plates under the beak, usually elevated on the margins to bound the sockets (*socket plates* or *ridges*). The crural bases may be united directly to the socket plates or may be attached by an *outer plate* (*divided hinge plate*). In some instances an *inner plate* unites the crural bases and welds the structures into a unit (*undivided hinge plate*). The inner plate is often perforated at its apex (*Athyris*) by a small foramen of uncertain function. In forms having a hinge plate the pedicle muscles are generally attached to the inner and outer plates. In orthids *fulcral plates* form the sockets and unite the brachiophore to the side wall of the valve (*Schizophoria*).

The cardinal process is the place of dorsal attachment of the diductor or opening muscles In a few terebratulids and rhynchonellids no process exists and the diductors are attached in a pit under the beak. More often the seat of attachment is a septum, boss, or some more complicated process. The cardinal process commonly consists of a *shaft* and a seat of muscular attachment, the *myophore*. The early orthids do not have a cardinal process but later forms have a simple septum. The dinorthid and hebertellid cardinal process is a short shaft with crenulate myophore. The punctate dalmanellids have a trilobate myophore. The triplesids and streptorhynchids have long shafts with forked myophore. In the terebratulids the cardinal process is generally a boss.

The dorsal valve is generally strengthened axially by median ridge or septum which separates a right and left pair of adductor scars. In the orthids the ridge is generally low and rounded except in a few aberrant forms in which it divides the valve into two chambers. The median septum may support the hinge plate or may buttress the *cruralium*, a subrostral cavity resembling the spondylium and formed by the convergence of *brachiophore* or *crural supports*. In some specialized types the septum supports the loop as well as the hinge plate.

CLASSIFICATION

Division of the Brachiopoda into two classes has been based hitherto on embryonic development, composition of shell substance, and presence or absence of articulating processes. In the **Inarticulata** (approximating **Gastrocaulia** Thomson) the pedicle develops within the valves of the first shell or *protegulum* and is later protruded. It is attached to the ventral valve only and the shell is generally chitinophosphatic, rarely calcareous. An anus is present, and the muscles are arranged for sliding the valves rather than rotating them on the teeth — a fact that will distinguish the calcareous Inarticulata. The **Articulata** (**Pygocaulia** Thomson) are characterized by development of the pedicle from the caudal segment of the embryo and the fact that it is seldom inclosed in the embryonic shell. An anus is absent in living members. The shell is always calcareous, and the valves are more or less strongly articulated.

Five orders of Brachiopoda are generally recognized — Atremata and Neotremata (Inarticulata); Palaeotremata, Protremata, and Telotremata (Articulata). These are based on the method of valve growth, position of pedicle opening, and modification of latter by accessory plates. For reasons to be discussed hereafter, it seems best to modify the classification of the Articulata. The complete classification to be used here follows:

Class **Inarticulata**
- Order **Atremata**
  - Superfamily OBOLACEA
  - Superfamily TRIMERELLACEA
- Order **Neotremata**
  - Superfamily PATERINACEA
  - Superfamily SIPHONOTRETACEA
  - Superfamily ACROTRETACEA
  - Superfamily DISCINACEA
  - Superfamily CRANIACEA

Class **Articulata**
- Order **Palaeotremata**
  - **Impunctate Articulata**
    - Superfamily ORTHACEA (including CLITAMBONACEA)
    - Superfamily SYNTROPHIACEA
    - Superfamily PENTAMERACEA
    - Superfamily TRIPLESIACEA
    - Superfamily RHYNCHONELLACEA
    - Superfamily SPIRIFERACEA (including ATRYPACEA, SPIRIFERACEA and ROSTROSPIRACEA)
  - **Pseudopunctate Articulata**
    - Superfamily STROPHOMENACEA
    - Superfamily PRODUCTACEA
  - **Punctate Articulata**
    - Superfamily DALMANELLACEA
    - Superfamily TEREBRATULACEA
    - Superfamily PUNCTOSPIRACEA

Atremata. The valves gape apically with pedicle attached to the ventral valve and forming a promi-

nent pedicle groove. Growth is confined chiefly to the lateral and anterior margins.

Neotremata. The pedicle usually is confined to a perforation at or near the apex of the ventral valve; growth, at least in ventral valve, is on all margins.

The **Articulata (Pygocaulia)** are generally subdivided into **Palaeotremata, Protremata,** and **Telotremata.** The first contains only two genera of primitive calcareous shells without fully developed articulation and delthyria. The Protremata are described as having delthyria in both valves, which are often more or less closed by a pseudodeltidium and chilidium. The brachial supports are rudimentary. The Telotremata, on the other hand, are described as having the delthyrium more or less closed by deltidial plates and the lophophore supported by crura, loops or spires. As a matter of fact these simple statements are misleading; in actuality the delthyria are variously modified.

Discovery of deltidial plates in the Protremata and what appears to be a pseudodeltidium in the Telotremata leads to confusion of the two orders. Add to these complications the presence of a loop in the impunctate, protremate *Enantiosphen* and the confusion becomes still greater. It seems best, therefore, in order to make separations easier, not to use the ordinal characters of the Protremata and Telotremata as defined but to arrange the superfamilies falling in these orders according to the three types of shell structure into which the Articulata are divisible. The arrangement above is not at present proposed as a genetic classification; it would require the demonstration that loops and spires were developed independently in the punctate and impunctate brachiopods. This is a possibility, but present knowledge does not permit such a demonstration. Nevertheless, it seems clear that the punctate and pseudo-punctate shells were derived from the impunctate Orthacea.

GEOLOGIC HISTORY

Reports of the existence of brachiopods prior to the Cambrian period have not been authenticated; but with the beginning of the Cambrian, representatives of three orders appear in force. Although these early brachiopods are all of primitive types they are, nevertheless, highly specialized along certain lines. Most early Cambrian brachiopods are inarticulate forms but several genera of Articulata (*Nisusia, Rustella, Kutorgina*) are known. In the late Cambrian, Orthacea and Syntrophiacea became common and in the late L. Ordovician (U. Canadian) the first of the pseudo-punctate genera of the Strophomenacea appeared. By M. Ordovician time the Pentameracea, Dalmanellacea, Rhynchonellacea, and Spiriferacea were well established, and with the M. Silurian the Productacea and Punctospiracea appeared. The Terebratulacea appeared in the late Silurian and by this time all of the major superfamilies have been established. The pseudopunctate forms evolved in the Pennsylvanian and Permian periods, into many genera, some of them bizarre types, after which they became extinct except for a possible few obscure incrusting types.

A great change took place in brachiopod assemblages after the Permian. The Spiriferacea and Punctospiracea disappeared in the Jurassic. At this time the Terebratulacea and Rynchonellacea became numerous. In the Tertiary the latter group declined, leaving the Terebratulacea as the commcn group in Cenozoic and modern seas.

Inarticulates were most abundant in the L. and M. Cambrian after which they occupied a position subordinate to the Articulata. Atremata and Neotremata are represented in modern seas, but, as in the late Paleozoic and the Mesozoic, they are less numerous in species and individuals than articulate types.

PREPARATION OF BRACHIOPODS FOR STUDY

In order to identify brachiopods it is necessary to reveal the structures of the interior. Because good natural interiors are very rare the paleontologist must find methods to determine the inside features of matrix-filled specimens. This may be done by mechanical or chemical means.

Mechanical Methods. Brachiopods may be cleaned by cementing isolated valves in a paraffin or plaster base and scraping away the covering matrix. The interior of either valve can be obtained by grinding off one valve and scraping out the interior filling, after which the shell can be freed from the protecting wax by xylol, or by dissolving the inclosing plaster in a 25% solution of sodium citrate. Muscle marks and septa can be revealed by roasting the shell to redness in the flame of a bunsen burner, cooling in air, and then scraping away the calcined shell with a needle cut to chisel edge. If these methods fail, the specimen may be ground or polished serially from the beak taking either cellulose peels or making drawings of the internal lamellae at definite intervals. This, of course, means destruction of the specimen; consequently, a replica and photograph should first be prepared.

Chemical Methods. Interior impressions of muscles and lamellae of brachiopod shells which occur in fine-grained sandstone or noncalcareous shale can be obtained by dissolving the shell with dilute acid. In complete specimens without regard to type of matrix, presence of septa can be revealed by washing the beaks with dilute acid and so thinning the shell as to make it translucent when wet. Silicified brachiopods can be freed completely from calcareous matrix by solution in dilute (5%) hydrochloric acid.

CLASS INARTICULATA

Order Atremata. Generally inarticulate, chitinophosphatic brachiopods; pedicle attached to ventral valve but opening for pedicle shared by both valves; pedicle groove in ventral valve; growth takes place

chiefly on anterior and lateral margins; specialized forms develop calcareous shell and inner platforms.

OBOLACEA. Shells with thickened and striated pedicle regions; ventral pedicle area traversed by a groove; life habits probably like those of modern *Lingula*.

LINGULELLA Salter 1886 (**105**—2)

(**Lingula davisi* McCoy). Linguiform in outline, rounded or elongate with bluntly pointed ventral apex; ventral beak with elongate pedicle attachment groove; dorsal beak with thickened inner margin; many species but of little stratigraphic value; abundant in **L. Camb.** to **L. Ord.**

L. similis Walcott (**107**—3–5). **U. Camb.:** S. Dak. (Deadwood), Okla., Tex.

L. ampla (Owen). **U. Camb.:** Wis., Minn.

LINGULEPIS Hall 1863

(**Lingula pinnaformis* Owen). Like *Lingulella* but with an elongate and acuminate ventral beak. **U. Camb.** (N. Y., Appalachians, Wis., Tex.).

***L. pinnaformis** (Owen) (**107**—1, 2). About 15 mm long, with long and slender ventral beak occupying one-fourth of valve length. **U. Camb.:** Wis.

L. walcotti Resser (**107**—6, 7). About the same size as preceding but with less slender beak and slightly more convex dorsal valve. **U. Camb.** (Nolichucky): S. Appalachians.

ELKANIA Ford 1886

(**Obolella desiderata* Billings). Subcircular in outline, biconvex, with inflated umbones; shells with high polish; posterior cystose; muscular fields deeply impressed in cystose areas. **U. Camb., L. Ord.** (Que.; Alaska; Nev.).

***Elkania desiderata** (Billings) (**107**—18, 19). **L. Ord.:** Que. (Levis).

LEPTOBOLUS Hall 1871

(**L. lepis*). Minute, subcircular to longitudinally oval, biconvex; ventral valve with distinct pedicle groove and elevated quadrate muscular area and long median ridge; dorsal valve thickened on cardinal margin, with slightly elevated trifid muscular impressions. **M.** and **U. Ord.** (S. Appalachians, Ohio, Ind.).

***L. lepis** Hall (**107**—15–17). **Trenton:** Ohio valley.

DICELLOMUS Hall 1871

(**Lingula? polita*). Shell small, polished, biconvex, oval to subcircular, generally thick-shelled; apices marginal; ventral valve with pseudointerarea and pedicle groove; interior with elongate visceral area; strong cardinal muscle scars and divergent pallial trunks; dorsal valve with flattened posterior margin, large cardinal muscles, and small central muscle scars located between two pallial trunks. **U. Camb.** (Appalachians, Wis., Mo., Black Hills, Cordilleran area).

***D. politus** (Hall) (**107**—8–14). **U. Camb.:** Appalachian area, Wis., Mo., Black Hills, Cordilleran area.

LINGULA Bruguière 1797

(**Patella unguis* Linnaeus). Shell generally shiny; valves subequal, linguiform, acuminate posteriorly, slightly gaping at both ends; ventral valve with small pseudointerarea and triangular pedicle groove, beak more acute than that of dorsal; dorsal valve with thickened posterior margin; musculature complex; many species but of little stratigraphic value. **Ord.–Recent.**

L. reevii Davidson (**107**—20). **Recent.**

Some important species: **L. elderi** Whitfield, **Black River; L. cobourgensis** Billings, **Trenton; L. iowensis** Owen, **Trenton; L. cuneata** Conrad, **Medina; L. punctata** Hall, **Hamilton; L. spatulata** Vanuxem, **Hamilton-Chemung; L. melie** Hall, **Kinderhook; L. subspatulata** Hall and Meek, **Cret.**

BARROISELLA Hall and Clarke 1890

(**B. campbelli* Cooper). Exterior like *Lingula*; ventral interior with elongate track and curved pallial impressions; dorsal valve with posterior triangular thickened area and elevated median ridge reaching beyond middle; generally occurs in black shale. **U. Dev., Miss.** (eastern N. America).

***B. campbelli** Cooper (= **B. subspatulata** Meek and Worthen) (**107**—29–32). **U. Dev.:** Mich., Ind., Ill.

TRIGONOGLOSSA Dunbar and Condra 1932

(**Lingula nebrascensis* Meek). Bluish-black in color, triangular in outline, compressed in profile; surface marked by distant raised concentric lines. **Miss., Penn.** (Ky., Mississippi Valley, Midcontinent, Tex.).

***T. nebrascensis** (Meek) (**107**—21). **Penn.:** Same distribution as genus.

LINGULASMA Ulrich 1889

(**L. schucherti*). Large; externally like *Lingula*; exterior sculptured by faint wavy lines and rows of papillae; muscular areas of both valves placed on elevated platforms, the dorsal platform supported by a long median septum. **M.** and **U. Ord.** (eastern half of U. S. A.).

***L. schucherti** Ulrich (**107**—25–28). **Richmond:** Ill.

TRIMERELLACEA. Large, inequivalved, with prominent ventral pseudointerarea; muscular areas elevated on platforms; shell calcareous.

DINOBOLUS Hall 1871

(**Obolus conradi*). Thick convex valves, dorsal subcircular, ventral oval; ventral beak acute, dorsal inconspicuous; a V-shaped muscular platform in both valves with apex of V anterior and the cavities beneath more conical than in *Trimerella*. **M. Sil.** (Ont.; Ohio, Ind., Wis., Ill.)

***D. conradi** (Hall) (**107**—22–24). **Niagaran:** Ohio, Ind., Wis., Ill., Ia.; England; Gotland.

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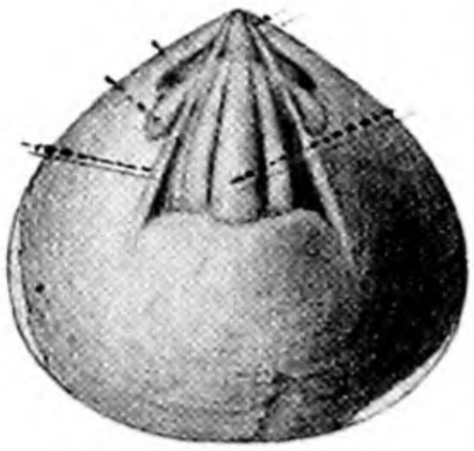

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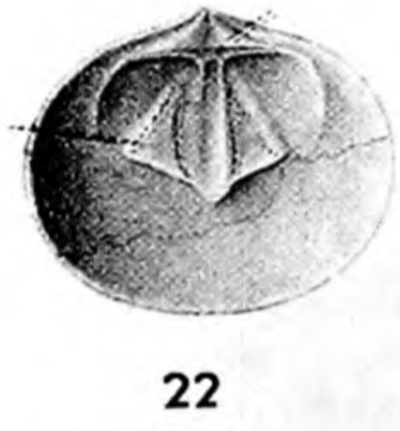

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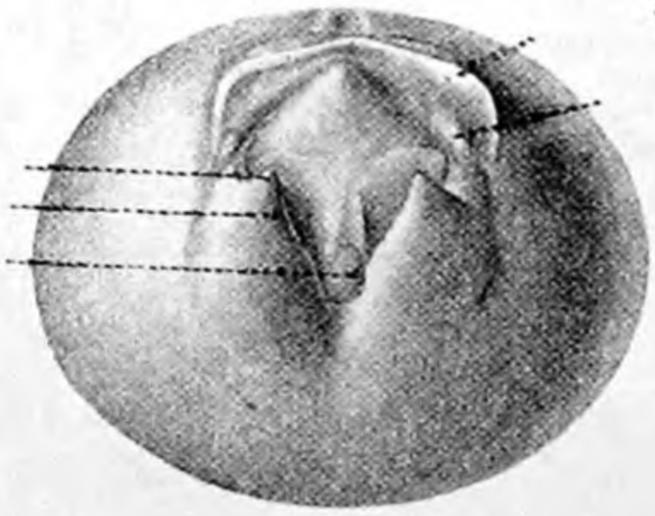

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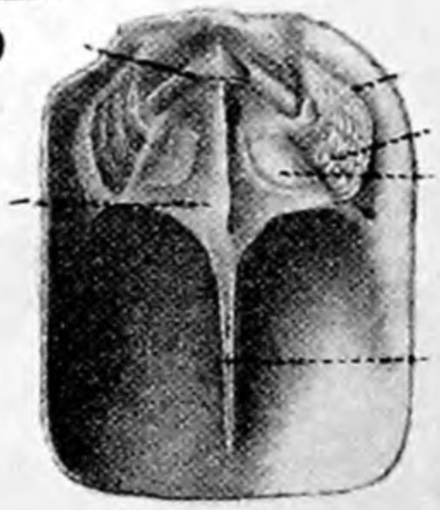

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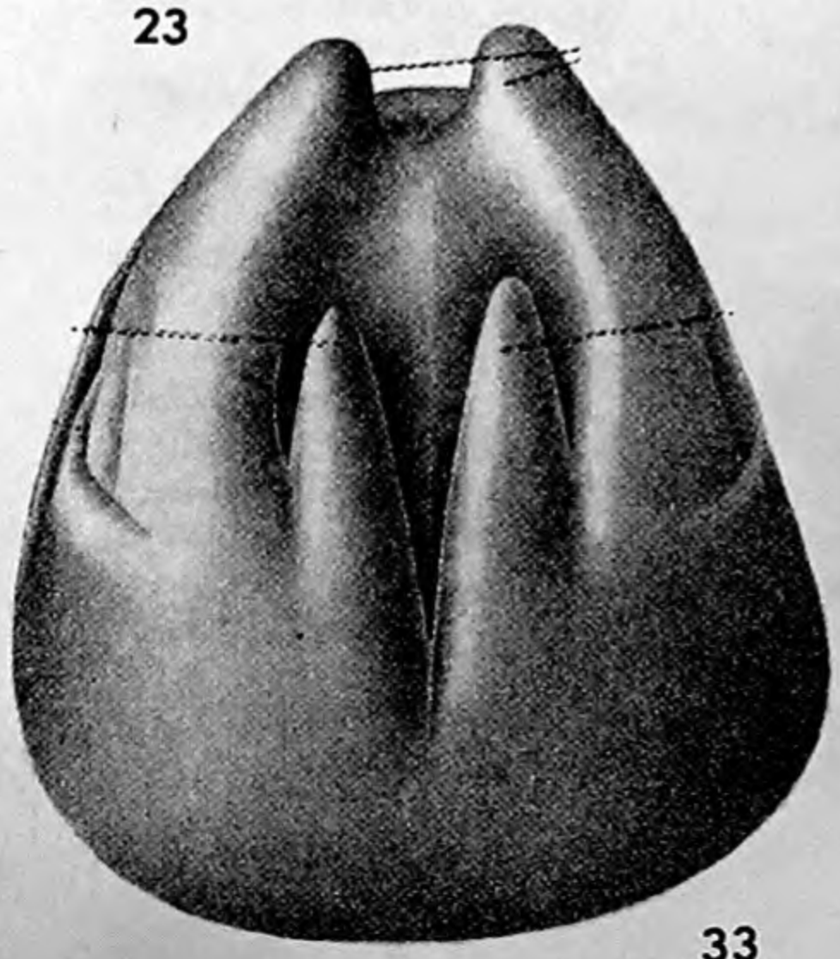

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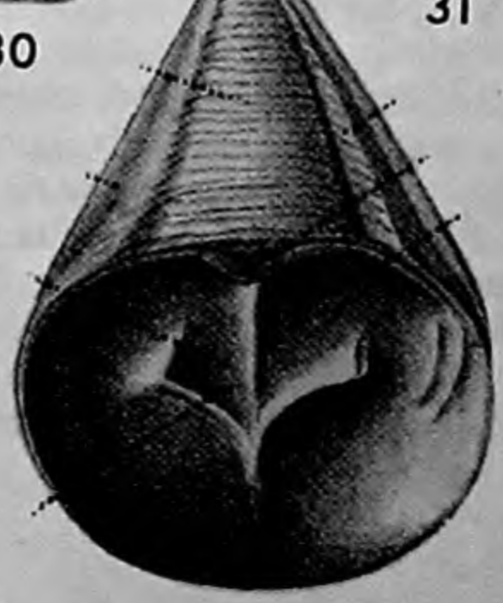

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MONOMERELLA Billings 1871

(**M. prisca*). Similar to *Dinobolus*, but with more elongate ventral valve and less prominent muscular platforms. **M. Sil.** (Ont.; Ohio, Ind., Wis., Ill.).

***M. prisca** Billings (**107**—34–36). **Niagaran:** Ont. (Guelph); Ohio, Ill.

TRIMERELLA Billings 1862

(**T. grandis*). Large, thick, calcareous, elongate-oval; platforms elongated and narrow with long narrow cavities beneath; usually occur as internal fillings or "steinkerns." **M. Sil.** (Ont.; Ohio, Wis., Ill.).

***T. grandis** Billings (**107**—33). **Niagaran:** Ont. (Guelph); Ohio, Wis.

T. ohioensis Meek (**108**—44–46). **Niagaran:** Ont. (Guelph); Ohio, Ill.

Order Neotremata. Chitino-phosphatic (or more rarely calcareous) shells with pedicle, when present, emerging through an opening in ventral valve or atrophied; dorsal valve generally conical; ventral valve more or less circular; growth holoperipheral in adult; one specialized group with cemented ventral valve and calcareous shells.

PATERINACEA. Small elliptical shells with ventral palintrope and delthyrium modified by a homoeodeltidium.

MICROMITRA Meek 1873

(**Iphidea? sculptilis*). Ventral valve gently convex; surface marked by elevated concentric lines and fine radiating ridges. **Camb.** (widespread throughout N. America).

***M. sculptilis** (Meek) (**108**—1–3). **M. Camb.:** Mont., Wyo.

PATERINA Beecher 1891 (**105**—7)

(**Obolus labradoricus* Billings). Like *Micromitra* in external form and structure but lacking radial ornamentation. Mostly **L.** and **M. Camb.** (widespread throughout N. America).

P. swantonensis Walcott (**108**—4–7). **L. Camb.:** Vt.

DICTYONINA Cooper 1942

(**Trematis pannulus* White). Like *Micromitra* and *Paterina* in external form and structure, but external ornamentation consisting of oblique raised lines which produce quincuncially arranged minute pits. **L.** and **M. Camb.** (Newf.; Appalachian area, Mont., Idaho, Utah, Nev.).

***D. pannula** (White) (**108**—12–14). **M. Camb.:** Nev.

SIPHONOTRETACEA. Elongate to subcircular shells having an apical foramen, which may or may not be anteroventrally migrant; dorsal beak marginal.

OBOLELLA Billings 1861

(**O. chromatica*). Valves nearly equal, longitudinally oval in outline; ventral valve with minute pedicle opening situated slightly anterior to beak. **L. Camb.** (widespread throughout N. America).

***O. chromatica** Billings (**108**—8–11). **L. Camb.:** Newf.; Labrador; N. Y.?

O. crassa (Hall). **L. Camb.:** Que.; Vt., N. Y.

YORKIA Walcott 1897

(**Y. wanneri*). Subcircular in outline; apex of ventral valve perforate; homoeodeltidium present; ventral muscular area longitudinally striated, large; dorsal valve with pseudointerarea; shell substance probably calcareous. **L. Camb.** (Pa., Va.).

***Y. wanneri** Walcott (**108**—18–20). **L. Camb.:** Pa. (Kinzers), Va.

SCHIZAMBON Walcott 1884

(**S. typicalis*). Generally circular to longitudinally oval in outline; shell thin and chitinous, ornamented by concentric undulations bearing long spines; ventral beak with pedicle foramen forming a long groove anterior to beak; dorsal valve rounder than ventral, with two prominent subapical muscular scars and four pallial trunks, two outer and two inner; ventral interior with two subapical muscle scars and a pair of subperipheral pallial trunks. **U. Camb.–M. Ord.** (Greenland; Que.; Mississippi Valley, Okla., western U. S. A.; Alaska).

***S. typicalis** Walcott (**108**—21–24). Shell small, subcircular, ventral valve slightly more convex than dorsal, foramen at end of elongate groove; surface marked by concentric lines and concentric rows of short spines. **U. Camb.:** Nev. (Similar species in **U. Camb.** of Que.; Colo., Utah, Alaska; B. C.)

ACROTRETACEA. Ventral valve conical and having a more or less long pseudointerarea modified by intertrough; foramen small, apical or dorsal to apex; dorsal beak marginal.

PLATE 107

[All figures are x1 and original by Cooper unless otherwise indicated.]

1, 2. Lingulepis pinnaformis [USGS, M 51]. V and D views. **3–5. Linguella similis** [USGS, M 51]. V int of type (x7); V ext (x4); D int (x6). **6, 7. Lingulepis walcotti** (x2). V and D exts. **8–14. Dicellomus politus** [USGS, M 51]. V int with longitudinal sections showing two types of preservation (x6, x9); D and V exts (x4, x5). **15–17. Leptobolus lepis** [N Y St Mus, An Rp 24]. V ext; D int; V int. **18, 19. Elkania desiderata** [GSA, SP 13]. Imp of V and D ints (x4). **20. Lingula reevii.** A modern brachipod with pedicle. **21. Trigonoglossa nebraskensis.** V ext. **22–24. Dinobolus conradi** [Pal N Y 8 (1)]. V int and Imp of same; D int of a large shell. **25–28. Lingulasma schuchertl.** Portion of surface enlarged (x4). D and V ints and S view of Int F [Pal N Y 8 (1)]. **29–32. Barroisella campbelli** (x2). V ext and int; D ext and int. **33. Trimerella grandis** [Pal N Y 8 (1)]. V view of Int F. **34–36. Monomorella prisca** [Pal N Y 8 (1)]. Imp of Dint; V int; mold of shell.

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ACROTHELE Linnarsson 1876

(**A. coriacea*). Chitinous, circular in outline with conical ventral valve having pedicle opening on posterior slope; dorsal valve gently convex; differs from *Acrotreta* in larger size and a long anterior slope on ventral valve; many similar appearing species. **M. Camb.** (Newf.; N. B., Que.; N. Y., Appalachians, Great Basin area, Rocky Mts. of Canada and U. S. A.).

A. colleni Walcott. **M Camb.:** Mont. (Gordon).

***A. coriacea** Linnarsson (**108**—15–17). **M. Camb.:** Sweden.

CONODISCUS Ulrich and Cooper 1936

(**Acrothele burlingi* Kobayashi). Valves the reverse of *Acrothele* with a conical dorsal valve, and a ventral valve concave anterior to the round foramen, but convex posterior to the foramen. **U. Camb.** (Alaska; Nev.).

C. burlingi (Kobayashi) (**108**—25–28). **U. Camb.:** Alaska.

ACROTRETA Kutorga 1848 (**105**—16, 17)

(**A. subconica*). Ventral valve a high cone with pseudointerarea and intertrough; pedicle opening posterior to apex; dorsal valve gently convex; surface marked by fine concentric lines; ventral interior with thick apical callosity and two strong pallial sinuses; dorsal valve with cardinal tubercles and long high median septum. Rare in **L. Camb.**; common in **M.** and **U. Camb.** of U. S. A. and Canada.

Many species from Cambrian rocks of N. America have been referred to *Acrotreta*, but as the type species is a European Ordovician form it is doubtful whether the Cambrian species conform strictly to the type. Some Cambrian species referred to this genus here are known to belong to *Prototreta* or *Homotreta* while others may ultimately be assigned to new genera. It is possible that *Acrotreta* = *Conotreta*.

A. ophirensis Walcott. **M. Camb.:** Utah.

A. idahoensis Walcott (**108**—34–39). **U. Camb.:** Idaho (St. Charles).

A. microscopica (Shumard). **U. Camb.:** Okla., Tex.

PROTOTRETA Bell 1938

(**P. trapeza*). Suggesting *Acrotreta* externally, apical portion of ventral valve with imperfect cone-in-cone structure; foramen posterior to apex; dorsal valve with high median septum expanded anteriorly into a plate having digitate extensions. **M. Camb.** (Cordilleran area).

***P. trapeza** Bell (**108**—29–33). **M. Camb.** (Meagher): Mont., Wyo.

P. attenuata (Meek). **M. Camb.:** Mont. (Meagher).

HOMOTRETA Bell 1941

(**H interrupta*). Small, outline subcircular or transversely subelliptical; ventral valve conical in profile; cone-in-cone structure not so strongly developed as in *Prototreta*; dorsal valve like *Prototreta* but with thin, high, bladelike median septum lacking digitate expansions. Some species now referred to *Acrotreta* may prove to belong to *Homotreta*. **M. Camb.** (Cordilleran area).

***H. interrupta** Bell (**108**—40–43). **M. Camb.:** Mont.

CONOTRETA Walcott 1889 (**105**—13)

(**C. rusti*). Like *Acrotreta* externally and internally but ventral valve with pallial trunks many branched. **M.** and **U. Ord.** (eastern U. S. A. and Canada).

***C. rusti** Walcott (**109**—1–3). **Trenton:** N. Y., Pa.

LINNARSSONELLA Walcott 1902

(**L. girtyi*). Shells small, ventral valve convex, beak incurved, foramen apical; ventral interior with strong divergent pallial trunks; dorsal valve gently convex; interior with two large subcardinal muscle impressions. **U. Camb.** (S. Dak., Mo., Okla., Tex., Utah, Nev.).

***L. girtyi** Walcott (**109**—4–8). **U. Camb.:** S. Dak. (Deadwood).

DISCINACEA. Circular, with conical dorsal valves; ventral valve with foramen located in a slit modified by a listrium.

TREMATIS Sharpe 1847

(**Orbicula terminalis* Emmons). Subcircular in outline; ventral valve unevenly convex, depressed posteriorly; apex median; pedicle fissure a deep cleft extending from apex to posterior margin; dorsal valve convex with submarginal beak and swollen umbo; surface ornamented by pits arranged in rows or quincunx; pits penetrate outer layer only. **M.** and **U. Ord.** (eastern Canada, Appalachians and Mississippi valley).

T. millipunctata Hall (**109**—9–12). Of medium size for the genus; transversely elliptical in outline;

PLATE 108

[All figures are x1 and after Walcott [USGS, M 51] unless otherwise indicated.]

1–3. Micromitra sculptilis. Apical view of type; D ext; S view of type. **4–7. Paterina swantonensis.** Post view of small Vv (x4); enlarged drawing of type (x2); two views of Dv (x8). **8–11. Obolella chromatica.** D and V exts (x4); Imp D and V ints (x5). **12–14. Dictyonina pannula** (x5). V and D exts; S view. **15–17. Acrothele coriacea.** D ext (x3); Imp V int (x4); V ext (x2.5). **18–20. Yorkia wanneri** (x2). V ext; Imp V and D ints. **21–24. Schizambon typicalis.** Portion of surface enlarged; V ext (x7); V and D ints (x5). **25–28. Conodiscus burlingi.** V ext (x3); S view (x2); Imp V int (x4); Imp D int (x3). **29–33. Prototreta trapeza** [JP 15] (x6). D ext and int; three views of Vv. **34–39. Acrotreta idahoensis** (x6). Three views of V ext; D int; Imp D and V ints. **40–43. Homotreta interrupta** [JP 15]. S and Post views of Vv (x6); D int (x6); D ext (x10). **44–46. Trimerella ohioensis** [Pal N Y 8 (1)]. D int; Post view of Int F; V int.

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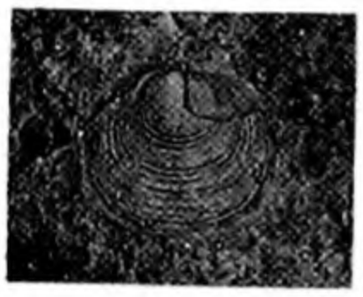

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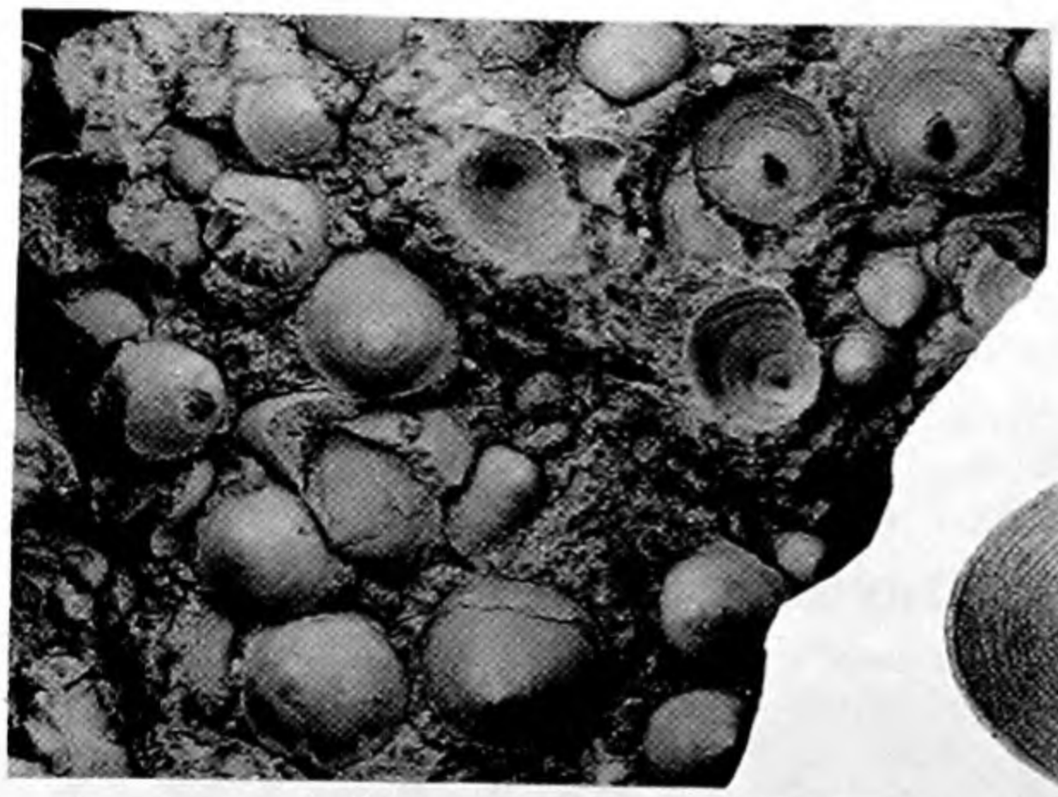

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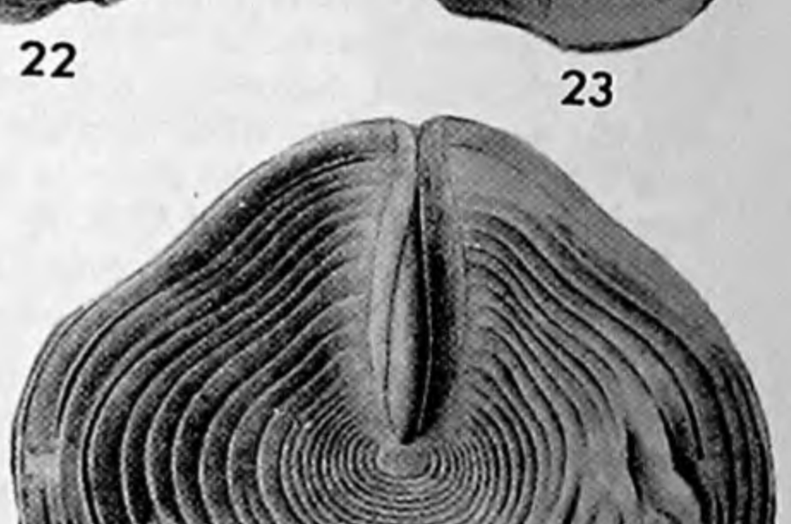

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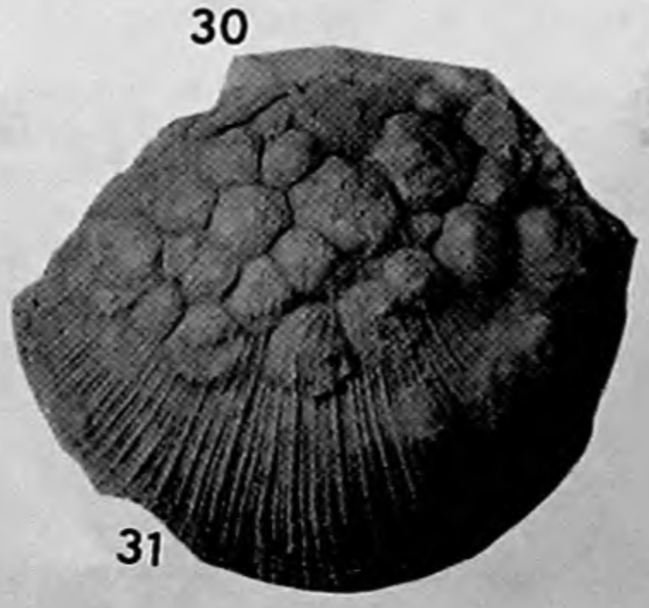

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pedicle notch deep; pits numerous, arranged in concentric rows. **U. Ord.:** Ohio, Ind., Ky.

***T. terminalis** (Emmons) (**109**—13–15). Differs from preceding in more circular outline and more convex ventral valve. **Trenton:** N. Y.

SCHIZOCRANIA Hall and Whitfield 1875

(**Orbicula? filosa* Hall). Inequivalved; subcircular in outline with dorsal valve ornamented by radial costellae, ventral valve marked by concentric lines; ventral valve flat or concave, with subcentral apex; pedicle notch deep and wide, extending from apex to posterior margin and partly closed by a listrium; dorsal valve convex, umbonate. **Ord.–L. Dev.** (Ohio Valley, Mississippi Valley).

***S. filosa** (Hall). (**109**—16–18). **U. Ord.** (Maysville, Richmond): Ohio Valley.

SCHIZOBOLUS Ulrich 1886

(**Lingula concentrica* Vanuxem). Oval, depressed-convex; ventral valve notched just posterior to apex, the foramen extending to posterior margin; dorsal valve with truncated posterior margin, nearly marginal apex and interior with a slender median septum. **Dev.** (top of Hamilton through Naples stage but most abundant in Geneseo shale and its equivalents). (N. Y., Appalachians, Ohio and Mississippi Valleys, Ark., W. Tex.)

***S. concentricus** (Vanuxem) (**109**—19–21). Range and distribution same as genus.

ORBICULOIDEA Orbigny 1847

(**O. forbesi* Davidson). Shell thin, usually shiny, subcircular with concentric apices and surface marked by concentric elevated lines and occasional fine radii; ventral valve depressed-convex or flattened; pedicle groove posterior to apex and extending almost to margin; just behind the beak this groove penetrates a long tube obliquely to interior of valve, where it opens near margin; dorsal valve conical; genus of little stratigraphic value. **Ord.–Perm.**

O. media Hall. **Dev.:** N. Y. (Geneseo).

O. missouriensis (Shumard) (**109**—24). **Penn.–L. Perm.:** (widespread throughout Midcontinent).

ROEMERELLA Hall and Clarke 1892

(**Orbicula grandis* Vanuxem). Large shells like *Orbiculoidea* but with the ventral valve concave. **M. Dev.** (Hamilton) (N. Y., Ind., Ky.).

***R. grandis** (Vanuxem) (**109**—25, 26). **Hamilton:** N. Y., Ind.

LINDSTROEMELLA Hall and Clarke 1890

(**L. aspidium*). Large, like *Orbiculoidea* in outline and profile but pedicle groove reaching margin and distal margins not united. **M. Dev.–Penn.**

***L. aspidium** H and C (**109**—27). Very large, separable from *Roemerella grandis* by elongate pedicle groove and undulation of concentric ridges as they approach the groove. **Hamilton:** N. Y., Pa.

DISCINISCA Dall 1871

(**Orbicula lamellosa* Broderip). Ventral valve flattened or concave, dorsal valve conical; apices subcentral; concentrically lamellose, occasionally with radiating lines; ventral valve with an impressed disk, elevated internally and surrounding the elongated foramen; interior with short median septum anterior to convex disk. **Mesozoic?–Recent.**

D. lugubris (Conrad) (**109**—22, 23). Shell small to large, subcircular to subelliptical with dorsal apex elevated, obtusely pointed, and situated about one-fifth the length from posterior margin; surface strongly lamellose with faint radiating lines on posterior slope. **Mioc., Plioc.:** N. J., Md., Va., S. C.

CRANIACEA. Aberrant, calcareous; circular or elliptical in outline, generally with cemented ventral valve and more or less conical dorsal valve.

PETROCRANIA Raymond 1911

(**Craniella meduanensis* Oehlert). Calcareous, endopunctate, outline irregular and often determined by nature of host; ventral valve cemented, dorsal valve a conical cap; ventral valve with two small central muscle scars separated by a short subcentral septum and two large posterior scars; dorsal valve with two pairs of scars, the smaller pair central, the larger pair just below posterior margin; surface marked by concentric growth lines only; genus of little stratigraphic value. **M. Ord.–Perm.?**

P. scabiosa (Hall) (**109**—31). **U. Ord.:** Ohio, Ind., Ky., Tenn., Wis.

P. hamiltoniae (Hall) (**109**—28–30). **Hamilton:** Ont.; N. Y., Pa., Mich., Ohio, Ind., Ky.

P. modesta (White and St. John). Widely distributed and ranging throughout the **Penn.**

PHILHEDRA Koken 1889

(**P. baltica*). Like *Petrocrania* in habit, profile, and outline but ornamented by elevated and marginally overlapping radial costellae; dorsal musculature the reverse of that of *Petrocrania*, the larger muscle scars

PLATE 109

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Conotreta rusti [USNM, Pr 12]. S, apical, and Ant views of Vv. **4–8. Linnarssonella girtyi** [USGS, M 51]. D ext (x6); V ext and S view (x6); Imp D int (x8); Imp V int (x8). **9–15. Trematis spp. 9–12. T. millipunctata** (x2). D, V, and S views [USGS, M 51]; V ext showing ornamentation. **13–15. T. terminalis** (x3). D int and Imp V int [USGS, M 51]; V ext showing ornamentation. **16–18. Schizocrania filosa.** Cluster of valves on *Rafinesquina*. Imp D int (x1.5) and V ext (x2) [Pal N Y 8 (1)]. **19–21. Schizobolus concentricus** (x4). D ext; V int; partly exfoliated V ext. **22, 23. Discinisca lugubris.** V ext and int. **24. Orbiculoidea missouriensis** (x2). Group of valves. **25, 26. Roemerella grandis** [Pal N Y 8 (1)]. D ext; V ext. **27. Lindstroemella aspidium** [Pal N Y 8 (1)]. V ext. **28–30. Petrocrania hamiltoniae.** V int; Dv on *Stropheodonta;* Imp D int (x2). **31. Petrocrania scabiosa.** Cluster of valves on *Rafinesquina*. **32, 33. Philhedra crenistriata.** D ext; V int (x3). **34. Philhedra laelia.** Cluster of valves on *Rafinesquina*. **35, 36. Craniops areolata.** Ext and int (x2).

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occupying the center of the valve; genus of little stratigraphic value. **M. Ord.–Perm.?**

P. laelia (Hall) (**109**—34). **U. Ord.** (Maysville, Richmond): Ohio, Ind., Ky., Tenn.

P. crenistriata (Hall) (**109**—32, 33). **Hamilton:** Ont.; N. Y., Pa., Mich., Ohio, Ind., Ky.

CRANIOPS Hall 1859

(= PHOLIDOPS Hall 1860)

(**Orbicula? squamiformis*). Small, oval to subcircular in outline, both valves depressed conical; ornamentation consisting of concentric lines; both valves with central muscular areas; genus widespread but of little stratigraphic value. **M. Ord.** (Trenton)**–L. Miss.**

C. areolata Hall (**109**—35, 36). **Onondaga:** Appalachians, Tenn.

Other important species: **C. trentonensis** (Hall), **Trenton; *C. squamiformis** (Hall), **Sil.; C. ovata** Hall, **Helderberg; C. hamiltoniae** (Hall), **Hamilton.**

CLASS ARTICULATA

Order Palaeotremata. Primitive brachiopods without fully developed articulation or delthyria; calcareous. **L. Camb.** (N. America).

RUSTELLA Walcott 1905

(**R. edsoni*). Profile lenticular, outline subcircular; surface marked by concentric growth lines and ridges only; pedicle groove rudimentary. **L. Camb.** (N. America).

***R. edsoni** Walcott (**110**—4). **L. Camb.:** Vt., Pa.

KUTORGINA Billings 1861

(**Obolella* (*Kutorgina*) *cingulata*). Profile concavo-convex, outline subelliptical; ventral valve strongly convex with much incurved beak; dorsal valve with convex umbo and concave anterior; delthyrium wide; deltidium and palintrope incipient. **L. Camb.** (Labrador; Que.; Vt., Va., Nev.; B. C.).

***K. cingulata** (Billings) (**110**—1–3). **L. Camb.:** Eastern U. S. A.

Impunctate Articulata. Shells impunctate.

ORTHACEA. With or without deltidium and chilidium; brachiophores small and cardinal process simple.

NISUSIA Walcott 1905

(**Orthisina festinata* Billings). The earliest and most primitive articulate brachiopod; ventral valve convex with large flattish palintrope; delthyrium covered by a convex pseudodeltidium flattened on top; foramen large, subapical; ventral interior with incipient dental plates; dorsal valve sulcate, gently convex in profile; brachiophores primitive; exterior multicostellate, with or without spines or costellae. **L.** and **M. Camb.** (N. America).

***N. festinata** (Billings) (**110**—5–7). Subquadrate, hinge equal to greatest shell width; ventral valve subconical with long palintrope and convex profile; dorsal valve sulcate; surface spino-costellate. **L. Camb.:** Labrador; Que.; Vt., Pa., Va.

N. spencei Walcott and **N. montanensis** Bell (**110**—8–11) are **M. Camb.** species of the Cordilleran area.

BILLINGSELLA Hall 1892 (**105**—9)

(**Orthis pepina*). Biconvex, quadrate to longitudinally semielliptical in outline; costellate; dorsal valve sulcate; ventral valve with broad palintrope, delthyrium covered by convex pseudodeltidium; foramen confined to deltidium; teeth large; vascula media prominent; dorsal valve with primitive brachial process, short median ridge, and chilidium. **U. Camb.**

B. perfecta Ulrich and Cooper (**110**—12–17). Small, quadrate to subcircular in outline; cardinal extremities rounded; ventral fold and interarea broad and flat; adductor track long, slightly elevated; pallial marks strong; dorsal valve with right-angled cardinal extremities. **U. Camb.:** Mont. (Dry Creek), Ariz. (Abrigo).

B. coloradoensis (Shumard). Larger and wider than *B. perfecta* and generally with acute cardinal extremities. **U. Camb.:** Tex. (Wilberns).

OCNERORTHIS Bell 1941

(**O. cooperi*). Small, subquadrate in outline; plano- to concavo-convex; anterior commissure sulcate; multicostellate; delthyrium open; dental plates absent; musculature and dorsal interior as in *Billingsella*. **U. Camb.** (Wyo.).

***O. cooperi** Bell (**110**—22–25). **U. Camb.:** Wyo. (Snowy Range).

WIMANELLA Walcott 1908

(**W. simplex*). Biconvex, ventral valve deeper than dorsal, umbo swollen; delthyrium and notothyrium open; ventral adductor muscle scar confined between

PLATE 110

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Kutorgina cingulata [USGS, M 51]. S, V, and D views. **4. Rustella edsoni** [USGS, M 51]. V ext of holotype. **5–7. Nisusia festinata.** V ext; Imp D int (x2); Imp V int. **8–11. Nisusia montanensis** (x2). Post, V, and D views of a complete specimen. D view of holotype [JP 15]. **12–17. Billingsella perfecta** [14: GSA, SP 13]. V ext and int; view showing deltidium (x4); V int (x3); D ext (x2); D int (x4). **18–21. Wimanella rossensis** [JP 15]. Imp V int (x2); Imp V int and apical view of same (x3); Imp D int (x2). **22–25. Ocnerorthis cooperi** (x3) [JP 15]. V ext and int; D ext and int. **26–28. Wimanella simplex** [JP 15]. Vv and Dv (x3); Imp D int (x2). **29–33. Eoorthis remnicha.** Imp V and D ints; D ext; V and D ints. **34–37. Apheoorthis lineocosta** (x2) [GSA, SP 13]. V ext and int; D ext and int. **38. Diraphora bellicosta** [JP 15]. Three Vv (x1.5). **39–42. Nanorthis hamburgensis** [GSA, SP 13]. V ext and int; D ext and int (Ints are x4; exts, x3). **43–46. Archaeorthis elongata** [GSA, SP 13]. V ext and int; D ext and int (Exts are x3; ints, x4). **47–50. Orthambonites eucharis** (x2) [GSA, SP 13]. D int and ext; V ext and int.

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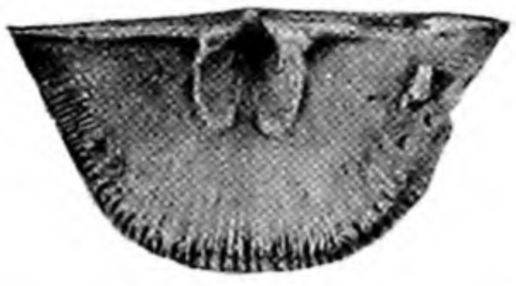
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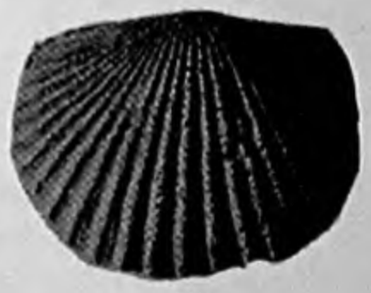
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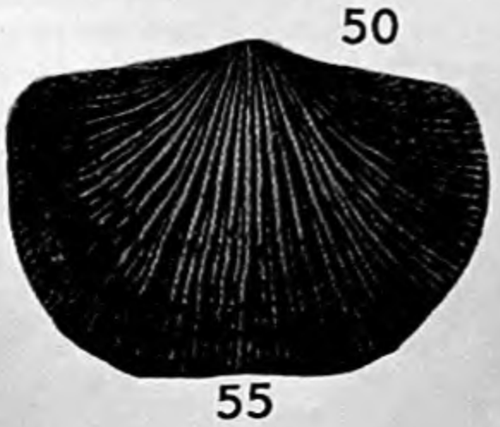
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anterior ends of diductor tracks; brachiophores billingselloid; exterior smooth or with faint radiating lines. **M. Camb.** (widespread).

W. appalachia (Walcott). **M. Camb.:** Appalachians.

***W. simplex** Walcott (**110**—26–28). **M. Camb.:** Mont. (Gordon).

W. rossensis Resser (**110**—18–21). **M. Camb.:** B. C. (Ross Lake).

DIRAPHORA Bell 1941

(**Eoorthis bellicosta* Walcott). Like *Wimanella* with open delthyrium and notothyrium but with exterior costellate. **M. Camb.** (Cordilleran area).

***D. bellicosta** (Walcott) (**110**—38). **M. Camb.:** B. C. (Burgess).

EOORTHIS Walcott 1908

(**Orthis remnicha* Winchell). Semiconical ventral valve with long palintrope, open delthyrium; dorsal valve gently convex, less deep than ventral; dental plates well developed; brachial apparatus like that of *Billingsella*; incipient cardinal process; surface costate, costae and interspaces covered by fine radial costellae. **U. Camb.** (Wis., Minn., Okla., Tex., Mont., Wyo.).

***E. remnicha** (Winchell) (**110**—29–33). **U. Camb.:** Wis., Minn., Okla., Tex., Mont., Wyo.

APHEOORTHIS
Ulrich and Cooper 1936 (**106**—5)

(**Eoorthis lineocosta* Walcott). Profile and outline like *Eoorthis* but surface fascicostellate; ventral valve with open delthyrium and pseudospondylium; dorsal valve internally like *Eoorthis*. **U. Camb., L. Ord.** (Appalachians, Arbuckles, Great Basin, Canadian and U. S. Rockies).

***A. lineocosta** (Walcott) (**110**—34–37). Slightly less than 25 mm in width, with obtuse cardinal extremities, ventral fold and dorsal sulcus; surface marked by concentric growth varices and crudely bundled costellae. **U. Camb.:** Colo. (Manitou). Similar species mark base of Ordovician in western U. S. A. and eastern and western Canada.

A. emmonsi Ulrich and Cooper. **U. Camb.:** Colo. (Sawatch?).

A. melita (Hall and Whitfield). **L. Ord.:** Nev. (Goodwin).

NANORTHIS Ulrich and Cooper 1936

(**Orthis hamburgensis* Walcott). Subcircular, biconvex, exterior costellate suggesting *Resserella* but shell impunctate; fold on ventral valve, dorsal sulcate; dental plates well developed; brachiophores simple rods supported by callus; incipient cardinal process. **L. Ord.** (Newf.; Que.; N. Y., Md., western U. S. A.; Canadian Rockies).

***N. hamburgensis** (Walcott) (**110**—39–42). **L. Ord.:** Colo., Utah, Nev.

N. putilla Walcott. **L. Ord.:** Alta., B. C.

ARCHAEORTHIS Schuchert and Cooper 1931

(**Orthis electra* Billings). Suggesting *Nanorthis* in outline, profile and ornamentation but generally with thicker shells; ventral interior with elongate callosity in front of muscle field; dorsal interior without cardinal process. **L. Ord.** (Newf.; Que.; Vt., western U. S. A.).

A. elongata Ulrich and Cooper (**110**—43–46). Shell small, length and width about equal, sides parallel, cardinal extremities auriculate; beak incurved; surface marked by costellae. **L. Ord.:** Nev. (M. and U. Pogonip).

A. glomerata Ulrich and Cooper. Larger than *A. elongata* with pronounced ventral fold and dorsal sulcus; costellae fasciculate. **L. Ord.:** Que.

A. costellata Ulrich and Cooper. **L. Ord.:** Nev. (U. Pogonip).

ORTHAMBONITES Pander 1830

(**O. transversa*). Biconvex, the ventral valve usually deeper than the dorsal, costate, subquadrate to subrectangular; interarea curved; delthyrium open; ventral interior with short, thick dental plates, subcordate muscular area, and vascula media subparallel in the median region; dorsal interior with short rodlike brachiophores, thickened notothyrial platform and simple cardinal process. **L.** and **M. Ord.** (Canadian–Chambersburg) (widespread).

O. eucharis Ulrich and Cooper (**110**—47–50). **L. Ord.:** Nev. (Pogonip).

O. michaelis Clark. **L. Ord.:** Utah, Nev.

HESPERORTHIS Schuchert and Cooper 1931
(**105**—5; **106**—3)

(**Orthis tricenaria* Conrad). Ventral valve convex with long palintrope; dorsal valve flat to concave; delthyrium partly closed by a short flat pseudodeltidium; brachiophores long, straight, triangular in section; cardinal process a simple ridge expanded anteroventrally. **M. Ord.** (Chazyan) to **M. Sil.**

PLATE 111

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–5. Hesperorthis tricenaria [3; Peabody Mus N H, M 4]. V int; S view; Post view (x1.5); D int and ext. **6–8. Dolerorthis flabellites.** D ext; V and D ints. **9–15. Glyptorthis** spp. **9–13. G. insculpta.** D int; S, V, and D views. V int (x1.5) [Peabody Mus N H, M 4]. **14, 15. G. bellarugosa.** D ext; V int. **16–20. Hesperonomia planidorsalis** [GSA, SP 13]. V ext and int (x2); D ext and int (x2); Post part of D int (x4). **21–24. Valcourea strophomenoides.** D exts (x1, x2); V ints (x2, x1). **25, 26. Valcourea ventrocarinata.** V and D exts. **27–31. Multicostella saffordi.** V, S, and D views; V and D ints. **32–35. Vellamo trentonensis.** Post view; D int and ext; S view. **36–41. Campylorthis deflecta.** S, apical, V, and D views; D and V ints. **42–48. Dinorthis** spp. **42–44. D. atavoides.** Apical, V, and D views. **45, 46. D. transversa.** S and V views. **47; 48. D. pectinella.** V and D views. **49–51. Retrorsirostra carleyi.** S and V views; V int. **52–58. Plaesiomys** spp. **52, 53. P. meedsi.** V and D exts. **54–58. P. subquadrata.** S, V, and D views; V and D ints.

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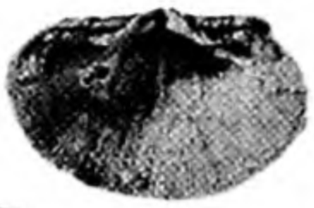
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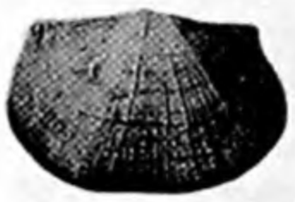
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(Niagaran) (Ottawa Valley; Appalachians, Midwest, Great Basin).

***H. tricenaria** (Conrad) (**111**—1–5). **M. Ord.** (Black River, Trenton): Widespread throughout eastern N. America.

DOLERORTHIS Schuchert and Cooper 1931

(**Orthis interplicata* Foerste). Like *Hesperorthis* internally but with convexity of valves reversed. **L. and M. Sil.**

D. flabellites (Foerste) (**111**—6–8). Semioval with wide hinge; strongly costate. **Niagaran** (Rochester): Ont.; N. Y., Appalachians, Ohio, Ind., Ky., Wis.

***D. interplicata** (Foerste). **Niagaran:** Ind. (Osgood).

GLYPTORTHIS Foerste 1914

(**Orthis insculpta* Hall). Internally like *Hesperorthis*, but with biconvex valves having strongly lamellose and costellate surface. **M. Ord.** (Chazy) to **L. Sil.** (Brassfield).

G. bellarugosa (Conrad) (**111**—14, 15). Small (about 10 mm long), subquadrate, valves subequal in convexity; dorsal valve sulcate. **Black River, L. Trenton:** Ottawa Valley; Mississippi Valley.

***G. insculpta** (Hall) (**111**—9–13). Larger and with more convex dorsal valve and less prominent lamellae than the preceding. **U. Ord.** (Richmond): Ohio and Mississippi Valleys.

VELLAMO Öpik 1930 (**106**—14)

(**Orthis verneuili* Eichwald). Ventral valve subpyramidal in profile with long interarea; dorsal valve flat; pseudodeltidium convex with large foramen; chilidium large and complete; ventral interior with spondylium simplex; dorsal valve having strong median ridge, short rodlike brachiophores supported by callus deposit and thick notothyrial platform with a simple ridge for cardinal process; chilidium and cardinal process often fused. **Ord.** (Trenton–Richmond) (Ont.; Ky., Minn., Mo.).

V. trentonensis Raymond (**111**—32–35). **M. Trenton:** Ottawa Valley; Minn.

HESPERONOMIA Ulrich and Cooper 1936

(**H. planidorsalis*). Shells wide, ventral valve gently convex, shallow, delthyrium open; dorsal valve flat or concave with simple cardinal process and chilidial plates. **L. Ord.** (U. Canadian) (S. Appalachians, Ozark Mts. of Ark., W. Texas, Great Basin, and Canadian Rockies).

***H. planidorsalis** U and C (**111**—16–20). **L. Ord.:** Alta (Sarbach).

H. antelopensis U and C. **L. Ord.:** Nev. (U. Pogonip).

H. crassa U and C. **L. Ord.:** Alta. (Sarbach).

VALCOUREA Raymond 1911

(**Placsiomys strophomenoides*). Convexi-concave in outline, ventral valve with prominent fold in posterior half; delthyrium generally covered with a pseudodeltidium; ventral muscle field quadrate; dorsal valve sulcate. **M. Ord.** (Chazyan to L. Trenton).

***V. strophomenoides** (Raymond) (**111**—21–24). Suggesting a small *Strophomena* but with a narrow median fold on the ventral valve and corresponding deep sulcus on dorsal. **Chazyan:** N. Y. (Crown Point). Smaller related species in U. Pogonip of Nev.

V. ventrocarinata Butts (**111**—25, 26). Larger than preceding and with a stronger fold. **M. Ord.:** Lenoir of S. Appalachians, Va. to Ala.

MULTICOSTELLA Schuchert and Cooper 1931

(**Orthis? saffordi* Hall and Clarke). Subquadrate in outline with a wide hinge and finely costellate ornamentation; valves biconvex; delthyrium open; interior like *Dinorthis*. **M. Ord.** (Chazyan and Black River) (Que.; Lake Champlain area; Appalachian Valley, Okla., Nev.).

***M. saffordi** (H and C). (**111**—27 31). **Chazyan:** Appalachians.

M. platys (Billings). **Chazyan:** Lake Champlain area of N. Y.

CAMPYLORTHIS

Ulrich and Cooper 1942 (**106**—17)

(**Strophomena deflecta* Conrad). Resembling *Multicostella* but with ventral valve concave in front half and delthyrium often covered with a pseudodeltidium. **M. Ord.** (Appalachians, Mississippi Valley).

***C. deflecta** (Conrad) (**111**—36–41). **M. Ord.** (Black River, Trenton): Mississippi Valley

C. magna (Schuchert and Cooper). **M. Ord.:** Okla. (Bromide).

DINORTHIS Hall and Clarke 1892

(**Orthis pectinella* Conrad). Generally large, strongly costate, convexi-concave; ventral muscular field

PLATE 112

[All figures are x1 and after Ulrich and Cooper [GSA, SP 13] unless otherwise indicated.]

1–3. Austinella kankakensis [original]. V, D, and S views. **4–8. Anomalorthis utahensis.** D and V exts (x2); S view; Post view of D int (x2); V int. **9–14. Tritoechia typica.** V ext and int; V apex; Post of Vv (x3); D ext and int. **15–18. Pomatotrema murale** (x2). V ext and int; D ext and int. **19–21. Polytoechia apicalis.** Apical view of Vv (x4); V and D exts (x3). **22–30. Finkelnburgia** spp. **22–27. F. bellatula.** V ext and int; Imp V int (x2); D ext and int (x2); Imp D int (x2). **28–30. F. armanda** (x2). V ext; Imp D and V ints. **31–33. Diparelasma typicum** (x2). D and V ints; D ext. **34–39. Desmorthis nevadensis.** V ext and int (x2); D int and ext (x2); D int (x3); detail of ornamentation (x4). **40. Plectorthis plicatella** [original]. D ext. **41–43. Plectorthis fissicosta** [Peabody Mus N H, M 4]. V and D exts; V int. **44–47. Mimella melonica** [Peabody Mus N H, M 4]. V int; V, D, and S views. **48–51. Doleroides gibbosus** [Peabody Mus N H, M 4]. V, D, and Post views; V int (x1.5). **52, 53. Hebertella frankfortensis** [original]. D ext; S view. **54–58. Mcewanella raymondi** [original]. V and D exts; D ext (x2); V int; D int (x2).

quadrate; dorsal cardinal process stout. **M.** and **U. Ord.**

D. atavoides Willard (**111**—42–44). Large with strong shells; ventral valve convex posteriorly but gently concave anteriorly; dorsal valve strongly convex, sulcus obscure; costae direct without bifurcation or intercalation. **M. Ord.:** S. Appalachians.

D. transversa Willard (**111**—45, 46). Wider than long; dorsal sulcus wide and moderately deep; ventral fold low, formed by several costae stronger than the surrounding ones; costellae bifurcating or intercalated. **M. Ord.:** S. Appalachians (Ottosee).

***D. pectinella** (Conrad) (**111**—47, 48). Large, with strong costae generally without intercalations; differs from *D. atavoides* in lesser thickness and from *D. transversa* in uniform nature of ribbing. **Trenton:** N. Y., Appalachians, Ky., Mississippi Valley.

RETRORSIROSTRA Schuchert and Cooper 1931 (**Orthis carleyi* Hall). Like *Dinorthis* (*Plaesiomys*) but with ventral palintrope steeply inclined in an anteroventral direction. **U. Ord.** (Ohio Valley, Tenn.).

***R. carleyi** (Hall) (**111**—49–51). **Richmond:** Ohio, Ind., Ky., Tenn.

PLAESIOMYS Hall and Clarke 1892 (**106**—8) (**Orthis subquadrata* Hall). Internally and externally like *Dinorthis* but with a multicostellate ornamentation. **M.** and **U. Ord.** (eastern N. America).

P. meedsi (Winchell and Schuchert) (**111**—52, 53). Generally small shells with unequally biconvex valves, the dorsal valve with the greater convexity; costellae increase by frequent intercalations. **M. Ord.** (Trenton): Mississippi Valley.

***P. subquadrata** (Hall) (**111**—54–58). Resembling **D.** (**P.**) **meedsi** but larger. **Richmond:** Ohio and Mississippi Valleys; Lake Winnipeg to Tex. and N. Mex. Related species in **Maquoketa** of Canada; Minn., Ia.

P. iphigenia (Billings). **M. Ord.** (Trenton): Ottawa Valley.

P. ulrichi (Foerste). **M. Ord.** (Trenton): Ky.

AUSTINELLA Foerste 1909 (**Orthis kankakensis* McChesney). Exterior with undivided costae but interior like *Dinorthis*; both valves strongly convex. **U. Ord.** (Baffin Land; Ohio and Mississippi Valleys).

***A. kankakensis** (McChesney) (**112**—1–3). **U. Ord.:** Ill. (Maquoketa).

A. whitfieldi (Winchell). **U. Ord.:** Wis., Ill., Minn., Ia.

ANOMALORTHIS Ulrich and Cooper 1936 (**A. utahensis*). Ventral valve subconical with long palintrope and small pseudodeltidium; dorsal valve gently convex, ventral interior with sessile spondylium; dorsal valve with simple brachial processes and a septumlike cardinal process. **L. Ord.** (Okla., Nev.).

***A. utahensis** U and C (**112**—4–8). **L. Ord.:** Utah (Swan Peak?).

A. nevadensis U and C. **L. Ord.** (U. Pogonip): Nev., Cal.

A. oklahomensis U and C. **L. Ord.:** Okla. (Oil Creek).

TRITOECHIA Ulrich and Cooper 1936 (**105**—10) (**Deltatreta typica* Ulrich). Ventral valve subconical; dorsal valve moderately convex; costellae closely crowded, often swollen and hollow; ventral valve with apically perforated pseudodeltidium; dorsal valve with short stout brachiophores supported by small obscure plates that meet floor of valve on each side of cardinal process; median ridge prominent. **L. Ord.** (U. Canadian). (Greenland; Newf.; eastern Canada; Appalachians, Okla., W. Tex., Great Basin, Canadian Rockies).

***T. typica** (Ulrich) (**112**—9–14). **L. Ord.:** Okla. (Alden).

POMATOTREMA Ulrich and Cooper 1932 (**P. muralis*). Like *Tritoechia* but with flat dorsal valve and more distant unequal costellae. **L. Ord.** (U. Canadian) (Greenland; Newf.; Que.; Okla.).

***P. murale** U and C (**112**—15–18). **L. Ord.:** Okla. (W. Spring Creek).

POLYTOECHIA Hall and Clarke 1892 (**Hemipronites apicalis* Whitfield). Biconvex, the ventral valve the deeper and usually hemipyramidal; ornamentation and dorsal interior as in *Tritoechia* but ventral valve with spondylium supported by two lateral septa besides the median septum. **L. Ord.** (U. Canadian) (N. Y., Ala., Ark., Arbuckles of Okla.).

***P. apicalis** (Whitfield) (**112**—19–21). **L. Ord.** (Cassin): Vt., N. Y.

P. alabamensis Ulrich and Cooper. **L. Ord.:** Ala. (Odenville), Ark. (Black Rock.)

FINKELNBURGIA Walcott 1905 (**F. finkelnburgi*). Biconvex, hinge generally narrower than greatest width; delthyrium open; ventral interior with spondylium; dorsal interior with short brachiophores supported by convergent plates that unite on each side of a simple cardinal process; dorsal adductors often elevated on four lobes of callus; small, unequally costellate forms in **U. Camb.** and **L. Ord.** (L. Canadian) of eastern and midwestern U. S. A. and Canada; subequally costellate types characterize middle and upper parts of **L. Ord.** (M. and U. Canadian) (Que.; Appalachians, Okla., Rocky Mts.).

F. bellatula Ulrich and Cooper (**112**—22–27). Shell small, slightly wider than long, length equal to about 0.87 times the width; costellae unequal, groups of three to six smaller ones separated by a coarser one. **L. Ord.:** N. J. (Kittatinny), Va. (Nittany), Mo. (Gasconade). A similar species is found in Chepultepec, Tribes Hill, and Stonehenge limestones.

F. armanda (Billings) (**112**—28–30). Large for the genus; characterized by right angular to acute cardinal extremities and strong costellae. **L. Ord.** (M. Canadian): Que.

DIPARELASMA Ulrich and Cooper 1936

(**D. typicum*). Small, subcircular in outline, biconvex, costellate; ventral interior with strong dental plates and muscular field often elevated on a pseudospondylium; dorsal valve with convergent brachiophore plates uniting with the median ridge. **L. Ord.** (U. Canadian) (Newf.; Que.; N. Y., Appalachians, Okla., W. Tex., Great Basin, and Canadian Rockies).

***D. typicum** U and C (**112**—31, 32). **L. Ord.:** Ala. (Odenville), Okla. (W. Spring Creek), Tex. (El Paso).

DESMORTHIS Ulrich and Cooper 1936

(**D. nevadensis*). Small, resembling *Plectorthis* externally but ventral valve with short pseudodeltidium and dorsal interior having a simple cardinal process; brachiophore supporting plates erect. **Ord.** (Okla., Nev., eastern Cal.).

***D. nevadensis** U and C (**112**—34–39). **L.** and **M. Ord.:** Okla. (Joins), Nev. (U. Pogonip).

PLECTORTHIS Hall and Clarke 1892

(**Orthis plicatella* Hall). Biconvex, costate; narrow hinged with strong dental plates in ventral valve; dorsal valve with brachiophores supported by convergent plates uniting with floor on each side of cardinal process. **Ord.** (Chazyan to Maysville).

***P. plicatella** (Hall) (**112**—40). Characterized by strong unbifurcated costae. **Trenton:** N. Y.; Ottawa Valley.

P. fissicosta Hall (**112**—41–43). Distinguished from preceding by its bifurcated costae along front margin. **Maysville** (Fairview): Ohio Valley.

MIMELLA Cooper 1930

(**Pionodema globosa* Willard). Biconvex, costellate; dorsal interior like *Hebertella* but ventral valve with trilobed muscular field. **M. Ord.** (Chazyan to Trenton) (N. Y., Appalachians, Okla.).

M. melonica Willard (**112**—44–47). Transversely elliptical to subcircular in outline, large; fold and sulcus poorly defined. **M. Ord.** (Ottosee): S. Appalachians, Va. and Tenn.

M. vulgaris Raymond. **Chazyan:** Champlain Valley.

DOLEROIDES Cooper 1930

(**Orthis gibbosa* Billings). Like *Mimella* externally but with ventral muscular field like *Hebertella*. **M. Ord.** (Black River, L. Trenton).

***D. gibbosus** (Billings) (**112**—48–51). **M. Ord.:** Eastern N. America.

D. ottawanus Wilson. **M. Ord.:** Ottawa Valley, N. Y.

HEBERTELLA Hall and Clarke 1892

(**Orthis sinuata* Hall). Shells generally large; ventral valve faintly convex to concave; dorsal valve deep and convex; ventral muscular area cordate in outline; adductor impressions elevated; dorsal interior as in *Mimella* and *Doleroides* and cardinal process with crenulated myophore. **Ord.** (Trenton to Richmond).

H. frankfortensis Foerste (**112**—52, 53). Smaller than usual in the genus and with straight, coarse undivided costae. **Trenton:** Ky., Tenn.

H. sinuata (Hall) (**113**—14–20). Large, costellate; dorsal valve much deeper than the ventral, with a strong fold. **Maysville** and **Richmond:** St. Lawrence Valley; Appalachians, Ohio Valley.

PLATYSTROPHIA King 1850

(**Terebratulites biforatus* Schlotheim). Generally large and having the external form of a *Spirifer* with a deep ventral sulcus and strong dorsal fold; both valves with prominent interareas; ventral valve with dental plates in young stages, the plates becoming obsolete with age; dorsal valve as in *Hebertella* but cardinal process generally without crenulated myophore and cardinalia much thickened by callus. **M. Ord.–M. Sil.**

Platystrophia with 2 primary costae in sulcus.

P. trentonensis McEwan (**113**—28, 29). Small, subrectangular in outline; cardinal extremities alate; 3 costae in sulcus, 4 on a low rounded fold, 12 to 15 on the flanks. **Trenton:** St. Josephs Island; Ky., Tenn., Minn., Ia.

P. reversata (Foerste) (**113**—26, 27). Large, resembling *Spirifer*; hinge narrow; fold high and with 5 to 7 costae; lateral costae 10 to 15 in number. **L. Sil.:** Ohio (Brassfield).

Platystrophia with 3 unmodified primary costae in sulcus and 4 on fold.

P. acutilirata (Conrad) (**113**—21–24). Attaining a width of 32 mm; hinge wide, cardinal extremities acute; fold low and rounded; flanks marked by 13 costae. **Richmond:** Ohio, Ind., Tenn., Wis., Ill.

P. crassa James (**113**—32–35). Small, slightly less than 19 mm in width, rectangular in outline; hinge width about equal to shell width; cardinal extremities a right angle; fold high, narrowly rounded; flanks with five or six costae. **U. Ord.** (Maysville): Ohio, Ind., Ky.

P. laticosta (Meek) (**113**—25, 30, 31). Large, about 32 mm along hinge; cardinal extremities alate; fold high, narrow; flanks marked by seven costae. **U. Ord.** (Maysville): Ohio, Ind., Ky., Tenn.

P. cypha James (**113**—36, 37). Like *P. laticosta* but with 9 or 10 costae on flanks. **U. Ord.** (Arnheim): Ohio, Ind., Ky.

P. ponderosa Foerste (**113**—41–44). Large, attaining a width of nearly 50 mm; hinge equal to or less than greatest width; fold low, broadly rounded; 7 to 9 costae on flanks. **U. Ord.** (Maysville–Richmond): S. Appalachians, Ohio, Ind., Ky., Tenn.

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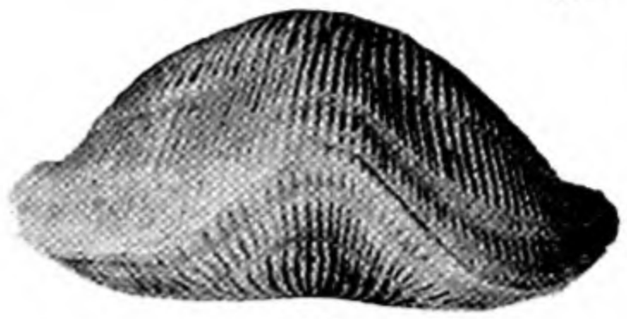
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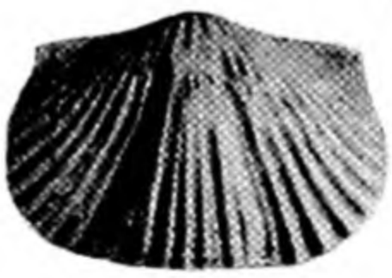
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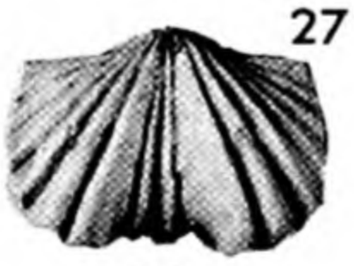
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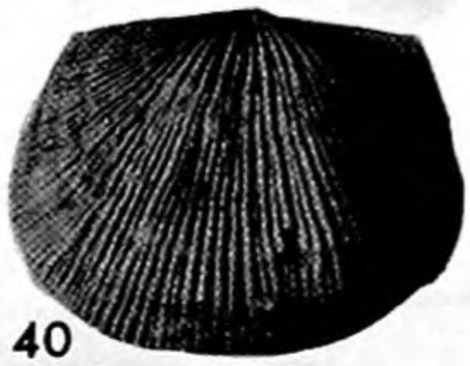
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MCEWANELLA Foerste 1920

(**Hebertella lineolata* Savage). Internally and externally like *Platystrophia* but with costae and interspaces covered with fine radiating lines. **Ord.** (Trenton? and Richmond) (Mo., Ark.).

M. raymondi Foerste (**112**—54–58). **U. Ord.:** Mo.

***M. lineolata** (Savage). **U. Ord.:** Mo.

ORTHOSTROPHIA Hall 1883

(**Orthis strophomenoides*). Subquadrate in outline, biconvex, costellate; ventral fold, dorsal sulcus; ventral musculature with wide and large adductor track, small diductor scars; pallial marks strong, like *Mimella*. **M. Sil.–L. Dev.** (eastern Canada; N. Y., Tenn., Okla.).

***O. strophomenoides** (Hall) (**113**—38–40). **L. Dev.** (New Scotland and equivalents): N. Y., Tenn., Okla.

O. sp. (**113**—13).

SKENIDIOIDES Schuchert and Cooper 1931

(**S. billingsi*). Minute but suggesting *Hesperorthis*; pyramidal ventral valve, dorsal valve plane or concave; ventral interior with spondylium; dorsal interior with long brachiophores supported by concave plates uniting with the high median septum. **M. Ord.–Sil.** (Ont.; Appalachians, W. Tenn., Mississippi Valley).

***S. billingsi** S and C (**113**—1–6). **Trenton:** Ottawa Valley.

SKENIDIUM Hall 1860

(**Orthis insignis*). Minute, externally and ventrally like *Skenidioides* but dorsal valve with outer plates attached to brachiophore bases to form a hinge plate. **L. Dev.** (N. Y., Appalachians, W. Tenn., Mo., Okla.)

***S. insigne** (Hall) (**113**—7–12). **L. Dev.:** N. Y., Tenn., Mo., Okla.

SYNTROPHIACEA. Biconvex, generally smooth shells usually with prominent ventral sulcus and dorsal fold; delthyrium never covered; ventral valve usually with spondylium; vascula media divergent; dorsal muscles not inclosed by dorsal lamellae.

PLECTOTROPHIA Ulrich and Cooper 1936

(**P. bridgei*). Transversely rectangular in outline, biconvex; ventral sulcus deep, with long tongue; dorsal fold subangular; ventral valve with spondylium; dorsal valve with two convergent plates that unite close together on the floor of the valve producing a V-shaped structure; flanks obscurely costellate. **U. Camb.** (Wis., Tex.; B. C.).

***P. bridgei** U and C (**114**—1–6). **U. Camb.:** Tex. (Wilberns).

PALAEOSTROPHIA Ulrich and Cooper 1936

(**Syntrophia* orthia Walcott). Like *Plectotrophia* internally but with subtriangular outline and smooth surface. **U. Camb.** (Que.; Wis., S. Dak., Tex.; B. C.).

P. elax (Clark) (**114**—7–12). **U. Camb.:** Que. (Levis in erratics); Vt.

P. perilla Walcott. **U. Camb.:** Alta. (Mons); Nev. (Goodwin).

HUENELLA Walcott 1908

(**Syntrophia texana*). Like *Plectotrophia* internally but with rounded fold and flanks; fold marked by a few strong costae. **U. Camb.** (Wis., Mont., Wyo., Tex.).

***H. texana** (Walcott) (**114**—15). **U. Camb.:** Tex. (Wilberns).

TETRALOBULA Ulrich and Cooper 1936

(**T. delicatula*). Small, transversely subelliptical to subcircular; dorsal fold strong; ventral valve with vascula media; dorsal interior with stout convergent supporting plates and quadrilobate, elevated muscular platform. **L. Ord.** (L. Canadian) (Tribes Hill of N. Y.; Chepultepec of Appalachians; and Gasconade zone of Ellenburger in central hill country of Tex.).

***T. delicatula** U and C (**114**—16–19). **L. Ord.:** Appalachians (Chepultepec).

SYNTROPHINA Ulrich 1928

(**Syntrophia campbelli* Walcott). Subcircular to subelliptical in outline, ventral sulcus and dorsal fold; surface smooth; ventral interior with spondylium; dorsal interior with two divergent supporting plates and a transverse muscle attachment at the apex. **L. Ord.** (L. and M. Canadian) (widespread throughout N. America).

***S. campbelli** (Walcott) (**114**—20–23). **L. Ord.:** Appalachians (Chepultepec), Mo. (Gasconade), Tex. (Ellenburger).

S. convexa (Kindle). **L. Ord.:** Alta. (Mons).

CLARKELLA Walcott 1908

(**Polytoechia? montanensis*). Exterior and ventral interior like *Syntrophina* but dorsal interior with four septa; range same as *Syntrophina*.

***C. montanensis** (Walcott) (**114**—13, 14). **L. Ord.:** Mont.

C. mcgerriglei Ulrich and Cooper. **L. Ord.:** Que. (Hastings Creek).

PLATE 113

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Skenidioides billingsi (x2) [Peabody Mus N H, M 4]. V, Post, S, and D views of a complete specimen; two D ints. **7–12. Skenidium insigne** (x3) [Peabody Mus N H, M 4]. Ant and D views; two Post views; V and D ints. **13. Orthostrophia** sp. Imp V int showing pallial markings. **14–20. Hebertella sinuata.** V, D, Ant, Post, and S views; D int [Peabody Mus N H, M 4]; V int. **21–37. Platystrophia** spp. **21–24. P. acutilirata.** D, Post, Ant, and V views. **25, 30, 31. P. laticosta.** V, D, and Post views. **26, 27. P. reversata.** V and D views. **28, 29. P. trentonensis.** D and Ant views. **32–35. P. crassa.** V, D, Post, and S views. **36, 37. P. cypha.** V and Ant views. **38–40. Orthostrophia strophomenoides.** V, S, and D views. **41–44. Platystrophia ponderosa.** V, D, Post, and Ant views.

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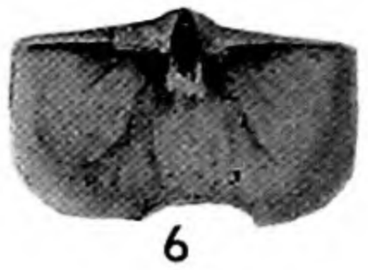
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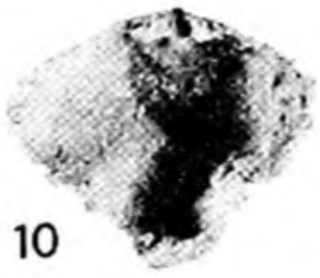
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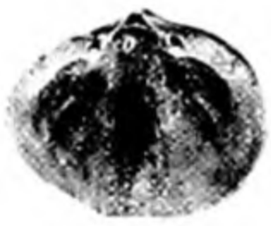
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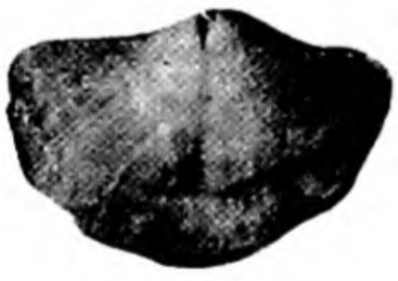
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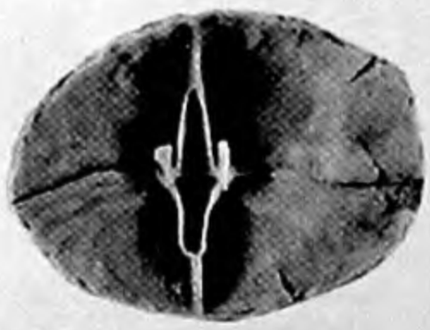
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C. nona (Walcott). **L. Ord.** (Mons): Alta., B. C.

DIAPHELASMA Ulrich and Cooper 1936

(**D. pennsylvanicum*). Exterior and ventral interior like *Syntrophina* but dorsal valve with two widely divergent and very short brachiophore supporting plates. **L. Ord.** (M. Canadian) (Newf.; Que.; Appalachians; Arbuckles; Tex., Rocky Mts.).

***D. pennsylvanicum** U and C (**114**—24–28). **L. Ord.:** Pa. (Longview), Va., Tenn.

D. quebecense U and C. **L. Ord.:** Que. (Hastings Creek).

SYNTROPHOPSIS Ulrich and Cooper 1936

(**S. magna*). Shells generally large, transversely elliptical, biconvex, smooth; ventral valve with spondylium, dorsal valve with two nearly parallel supporting plates but no apical muscle callosity. **L. Ord.** (U. Canadian) (Newf.; Que.; Appalachians, Ozarks, Arbuckles, W. Tex.; Great Basin; Canadian Rockies).

***S. magna** U and C (**114**—32–35). **L. Ord.:** Ala. (Odenville), Ark. (Black Rock), Tex. (El Paso).

S. obscura (Hall and Whitfield). **L. Ord.:** Nev. (Pogonip); Alta. (Sarbach).

SYNTROPHIA Hall and Clarke 1892

(**Triplesia lateralis* Whitfield). Externally like *Syntrophopsis*; ventral interior with spondylium supported by short median septum; dorsal interior with small cruralium. **L. Ord.** (Lake Champlain area of Vt. and N. Y., Ark.).

***S. lateralis** (Whitfield) (**114**—29–31). **L. Ord.** (Cassin): Champlain Valley.

CAMERELLA Billings 1859

(= RHYNCHOCAMARA Schuchert and Cooper 1931) (**C. volborthi*). Shells generally subtriangular to subcircular in outline, biconvex, generally anteriorly costate; interarea rudimentary, delthyrium open; ventral valve with spondylium duplex; dorsal valve with small cruralium. **L.** and **M. Ord.** (U. Canadian to Trenton) (Newf.; Que.; N. Y., Appalachians, Central Basin of Tenn., Mississippi Valley, Okla., Great Basin).

C. varians Billings. **Chazy:** Mingan Isls., Que.; Champlain Valley, Tenn.

***C. volborthi** Billings (**114**—36–38). **L. Trenton:** Ottawa Valley.

C. plicata (Schuchert and Cooper) (**114**—39–43). **M. Ord.:** Tenn. (Ridley).

PARASTROPHINA Schuchert and Levene 1929

(**Atrypa hemiplicata* Hall). Circular to transversely slightly elliptical in outline, elliptical to subcircular in profile, hinge narrow, delthyrium open; surface costate in front half; ventral interior with spondylium duplex; dorsal interior with long cruralium and lateral winglike plates on each side. **M. Ord.** (Vt., N. Y., Appalachians; Ottawa Valley; U. Mississippi Valley; Man.).

***P. hemiplicata** (Hall) (**114**—44–47). **Trenton:** Vt., N. Y., Appalachians, Ottawa Valley.

ANASTROPHIA Hall 1867 (**106**—6, 11)

(**Pentamerus verneuili*). Globular in outline and profile, with valves completely costate; costae often bifurcating; ventral interior with spondylium duplex; dorsal interior with subparallel plates supporting curved brachial processes and with alate plates on each side as in *Parastrophina*. **Sil., Dev.**

A. internascens Hall (**114**—53–55). Small, globular, costate; ventral sulcus wide, containing five costae; fold low, rounded; costae with few intercalations. **M. Sil.:** N. Y., Ind., W. Tenn., Wis., Okla.

***A. verneuili** (Hall) (**114**—48–52). Shell resembling the preceding but larger. **L. Dev.** (New Scotland and equivalents): Greenland; N. Y., Appalachians, W. Tenn., Mo., Okla.

PENTAMERACEA. Large biconvex shells with ventral spondylium duplex and dorsal muscle field confined within the cruralium or dorsal lamellae.

BARRANDELLA Hall and Clarke 1893

(**Atrypa linguifera* Sowerby). Transversely elliptical in outline, strongly biconvex, smooth surface; ventral sulcus, dorsal fold; dorsal valve with brachial plates convergent to a median septum and including the adductors. **M. Sil.** (Anticosti; Que.; N. Y., Ohio, Ind., Ky., Tenn., Ark.).

B. fornicata (Hall) (**114**—56–58). Ventral valve convex; surface broadly and obscurely plicate. **M. Sil.** (Clinton): N. Y., Appalachians, Ind., Wis.

GYPIDULA Hall 1867

(**Pentamerus occidentalis*). Generally elongate oval to subcircular in outline; ventral beak arched over dorsal; strong ventral fold, dorsal sulcus; dorsal interior with discrete plates uniting with floor of valve. **M. Sil.** through **Chemung.** (N. B., Que.; N. Y., Appalachians, Midwest; Mackenzie Valley, Man.; Rocky Mts., Great Basin; Alaska).

PLATE 114

[All figures are x1 and after Ulrich and Cooper [GSA, SP 13] unless otherwise indicated.]

1–6. Plectotrophia bridgei. Ext and Ant views of Vv (x2); fragment showing delicate ornamentation (x3); D int and ext (x2); V int (x2). **7–12. Palaeostrophia elax** (x2). V ext and int; D ext and int; S view of Vv and Dv. **13, 14. Clarkella montanensis.** D and V exts (x1.5). **15. Huenella texana** (x2). Part of slab showing D and V exts. **16–19. Tetralobula delicatula.** V and D exts (x3, x2); D and V ints (x3). **20–23. Syntrophina campbelli.** V and D exts (x2); Imp V and D ints (x3). **24–28. Diaphelasma pennsylvanicum** (x1.5). V ext and int; D int; D ext; D int. **29–31. Syntrophia lateralis** (x2). Post, V, and D views. **32–35. Syntrophopsis magna.** D and S views; V and D ints (x1.5). **36–43. Camerella** spp. [original]. **36–38. C. volborthi.** D, S, and Ant views (x2). **39–43. C. plicata** (x2). V and D views of a coarsely ribbed specimen; V and D views of a finely ribbed shell; V int. **44–47. Parastrophina hemiplicata** [original]. D, V, and S views; Int (x2). **48–55. Anastrophia** spp. **48–52. A. verneuili.** D, V, and S views [original]; V and D ints [Peabody Mus N H, M 4]. **53–55. A. internascens** [original]. D, V, and S views. **56–58. Barrandella fornicata** [Pal N Y 8 (2)]. D, V, and S views.

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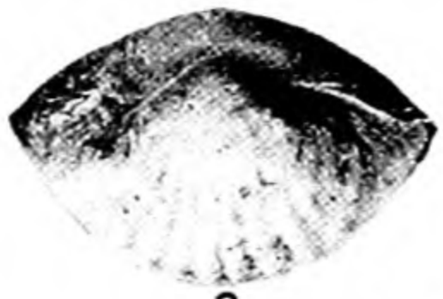
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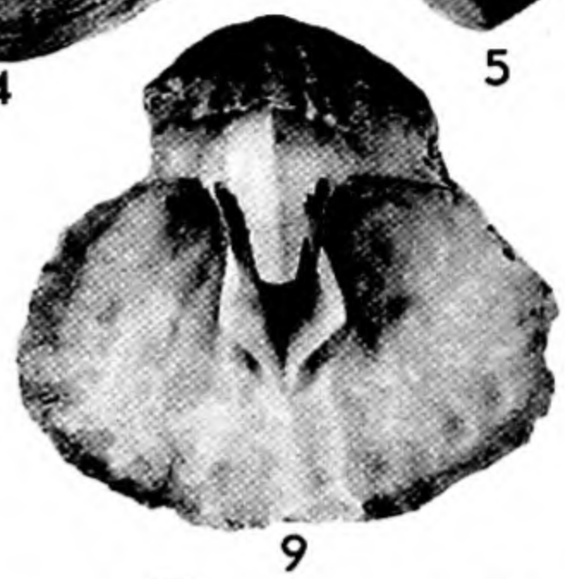
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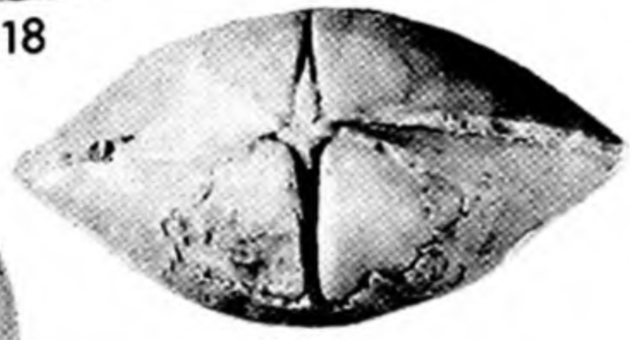
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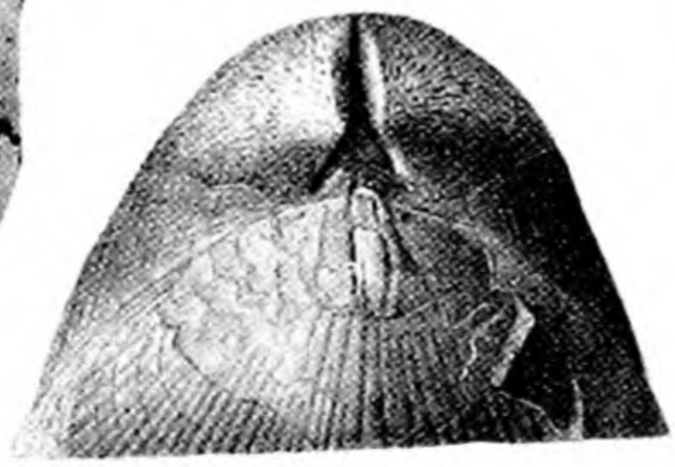
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G. coeymanensis Schuchert (**115**—1–3). Large, about 38 mm long; ventral valve convex with beak arching over dorsal; fold low, wide, sulcus shallow; valves costate, costae strongest on fold and sulcus. **L. Dev.** (Coeymans): N. Y., Appalachians.

G. pseudogaleata (Hall) (**115**—6, 7). Large, suggesting *G. coeymanensis* but noncostate. **L. Dev.** (Becraft): N. Y., Appalachians.

G. loweryi Merriam (**115**—4, 5). Very large, smooth and with very convex valves. **Dev.:** Nev. (Nevada).

G. comis (Owen) (**115**—10, 11). About 25 mm long; ventral valve with strongly arched beak; fold wide but low and short; costae developed at anterior only, three in sulcus, four on fold; three to four costae on anterior part of lateral slopes. **M. Dev.:** Ia. (Cedar Valley).

G.? romingeri Hall and Clarke (**115**—8, 9). Atypical; large with strongly convex ventral valve having arching beak and faint fold; dorsal valve slightly convex with broad shallow sulcus; anterior commissure straight to slightly sulcate; anterior and median portions costate. **Hamilton, Traverse:** Mich. (Genshaw).

SIEBERELLA Oehlert 1887

(**Pentamerus sieberi* Buch). Like *Gypidula* externally but with the dorsal plates converging to unite with a low median septum. **Sil.** to **U. Dev.**

S. roemeri Hall and Clarke (**115**—12, 13). Suggesting a small *Gypidula coeymanensis* but more rounded and shorter. **M. Sil.:** W. Tenn. (Brownsport), Okla. (Henryhouse).

PENTAMERELLA Hall 1867

(**Atrypa arata* Conrad). Multicostate, biconvex, ventral sulcus, dorsal fold; interior like *Gypidula*. **Dev.** (Ont.; N. Y., Appalachians, Midwest, Mich.; rare in Great Basin).

***P. arata** (Conrad) (**115**—19–22). Above 25 mm in length and width; ventral valve strongly convex, dorsal gently convex; sulcus very shallow, fold low, marked by the strongest costae; flanks multicostate. **Dev.** (Onondaga): Ont.; N. Y., Ohio, Ind.

P. pavilionensis (Hall) (**115**—16–18). Resembling preceding but smaller, with fewer costae and more strongly developed fold. **M. Dev.** (Hamilton and Tully): Ont.; N. Y., Pa., Ohio, Ind., Ky.

P. obsolescens (Hall) (**115**—14, 15). Small, less than 12 mm in width, smooth except for median portion of margin where a few rounded costae appear; fold and sulcus not strongly developed. **M. Dev.:** ?Mich. (Traverse), Ia. (Cedar Valley), ?Mo.

CONCHIDIUM Hisinger 1799

(**C. bilocularis*). Shells internally like *Pentamerus* but externally costate and with ventral beak greatly elongated and arched over dorsal valve. **M.** and **U. Sil.** (N. B., Que., Ont.; Appalachians, Ohio and Mississippi Valleys, W. Tenn., Great Basin; Alaska).

C. laqueatum (Conrad) (**116**—6, 10–12). Longer than wide, beak fairly long and moderately incurved; costae strong, subangular. **M. Sil.:** Ind. (Huntington).

C. occidentale (Hall). Similar to *C. laqueatum* but with longer beak and finer and more subdued ornamentation. **M. Sil.** (Guelph): Ont.; Wis.

"C. knighti" type (**116**—5). Large, attaining a length and width of 10 cm; beak strongly incurved; costae strong. **U. Sil.:** S. E. Alaska; England.

PENTAMERUS Sowerby 1813

(**P. oblongus* Sowerby = *P. laevis* Sowerby). Large, biconvex, smooth; ventral beak arching over dorsal umbo; anterior often trilobed; ventral valve with long spondylium duplex; dorsal valve with two long subparallel plates supporting long curved brachial processes. **M. Sil.** (Que.; Ont.; N. Y., Appalachians, Mississippi Valley; Alaska).

***P. laevis** Sowerby (**116**—2–4, 8, 9). Elongate lenticular in profile, pentagonal in outline. Range and distribution same as genus.

P. cylindricus Hall and Whitfield (**116**—7). **Niagaran:** Ind., Ky.

PENTAMEROIDES Schuchert and Cooper 1931

(**Pentamerus subrectus* Hall and Clarke). Externally like *Pentamerus* but dorsal interior has an elongate cruralium, **M. Sil.** (N. B., Que.; Mich., Wis., Ia.).

***P. subrectus** (H and C) (**115**—23, 24). **Niagaran:** Wis., Ia.

RHIPIDIUM Schuchert and Cooper 1931

(**Pentamerus knappi* Hall and Whitfield). Outline, profile, and interior like *Pentamerus* but radially costate. **M. Sil.** (Ky., W. Tenn.)

***R. knappi** (H and W) (**115**—29, 30). **Niagaran:** Ky. (Louisville), W. Tenn. (Brownsport).

BROOKSINA Kirk 1922

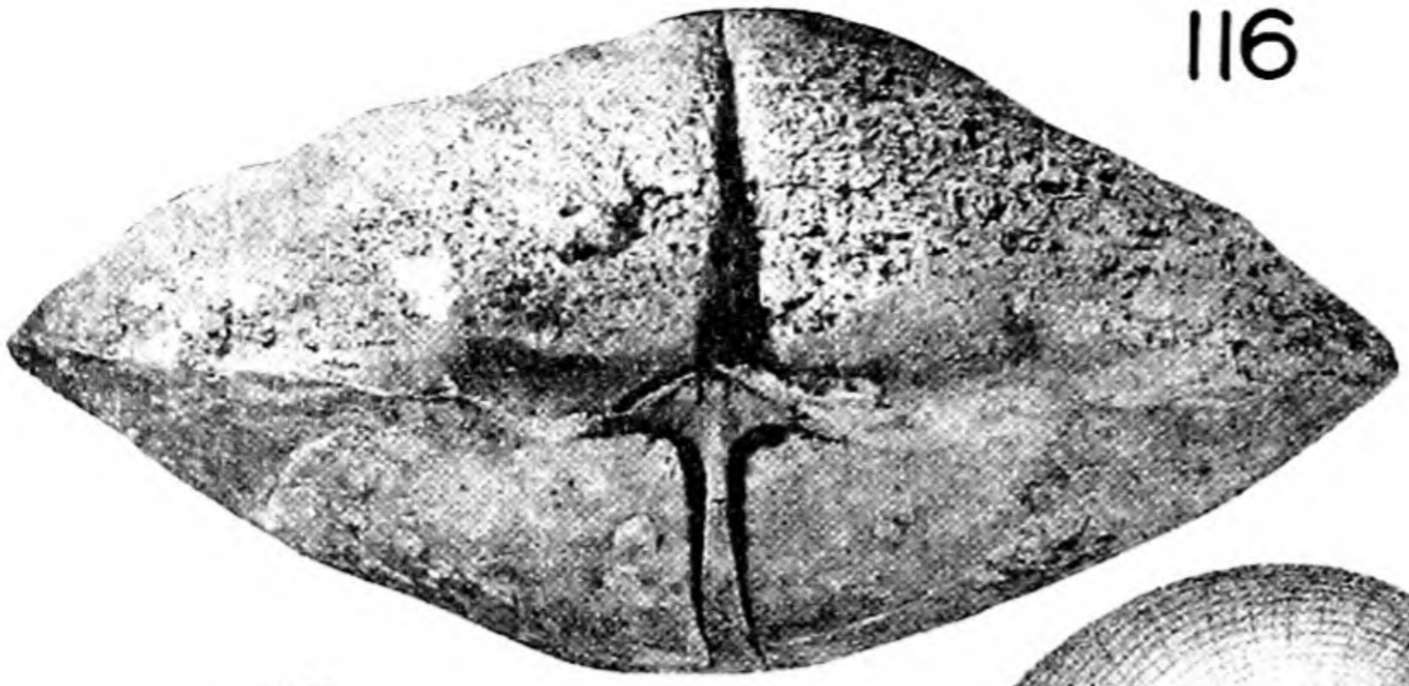
(**B. alaskensis*). Internally like *Conchidium* but with concave ventral valve; finely multicostate. **M.** and **U. Sil.** (W. Tenn.; S. E. Alaska).

***B. alaskensis** Kirk (**115**—31–33). **U. Sil.:** S. E. Alaska.

PLATE 115

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–11. Gypidula spp. 1–3. G. coeymanensis. V, S, and Post views [Peabody Mus N H, M 4]. **4, 5. G. lowryi.** D and S views. **6, 7. G. pseudogaleata.** D and S views. **8, 9. G. romingeri.** D ext and int. **10, 11. G. comis.** S and D views. **12, 13. Sieberella roemeri.** S and D views. **14–22. Pentamerella spp. 14, 15. P. obsolescens.** D and Post views. **16–18. P. pavilionensis.** V, S, and D views. **19–22. P. arata** [Pal N Y 8 (2)]. V ext and int; D ext and int. **23, 24. Pentameroides subrectus.** D and Post views of Int F. **25–27. Virgiana decussata** [Pal N Y 8 (2)]. Post part of shell viewed dorsally; V and D views. **28. Virgiana barrandei.** D view. **29, 30. Rhipidium knappi.** S and D views. **31–33. Brooksina alaskensis.** Longitudinal section through beaks showing septa; S and V views.



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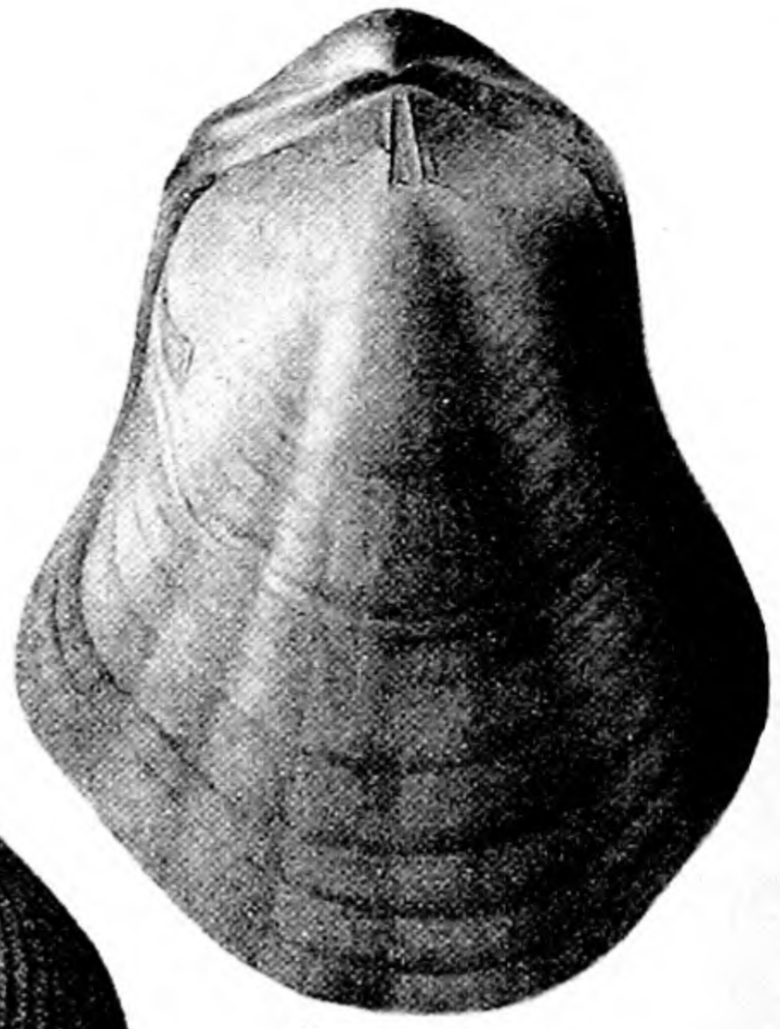

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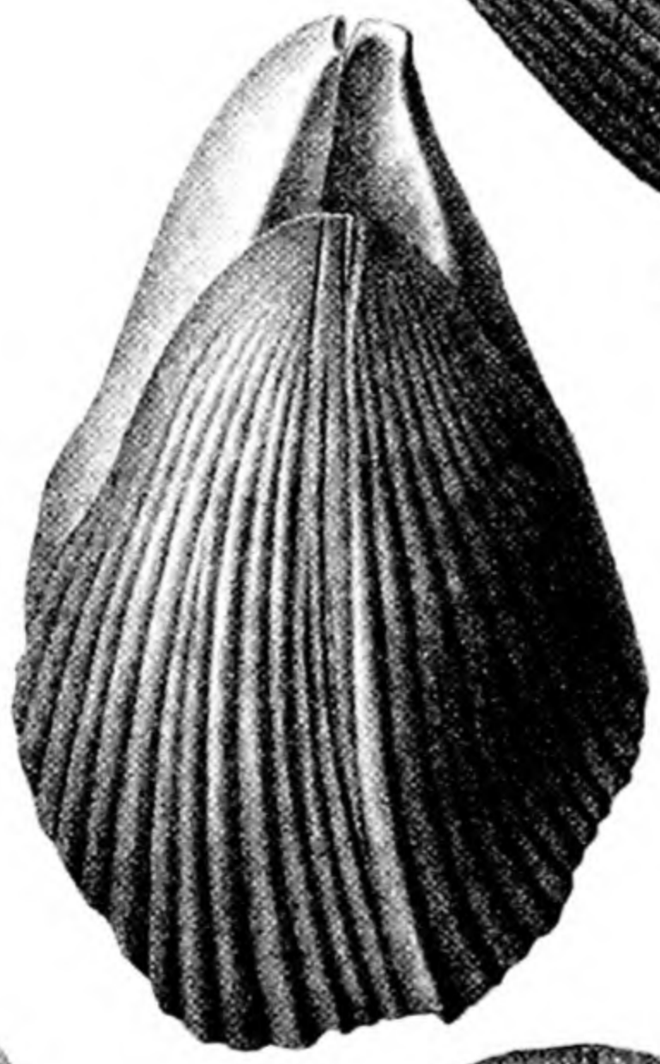

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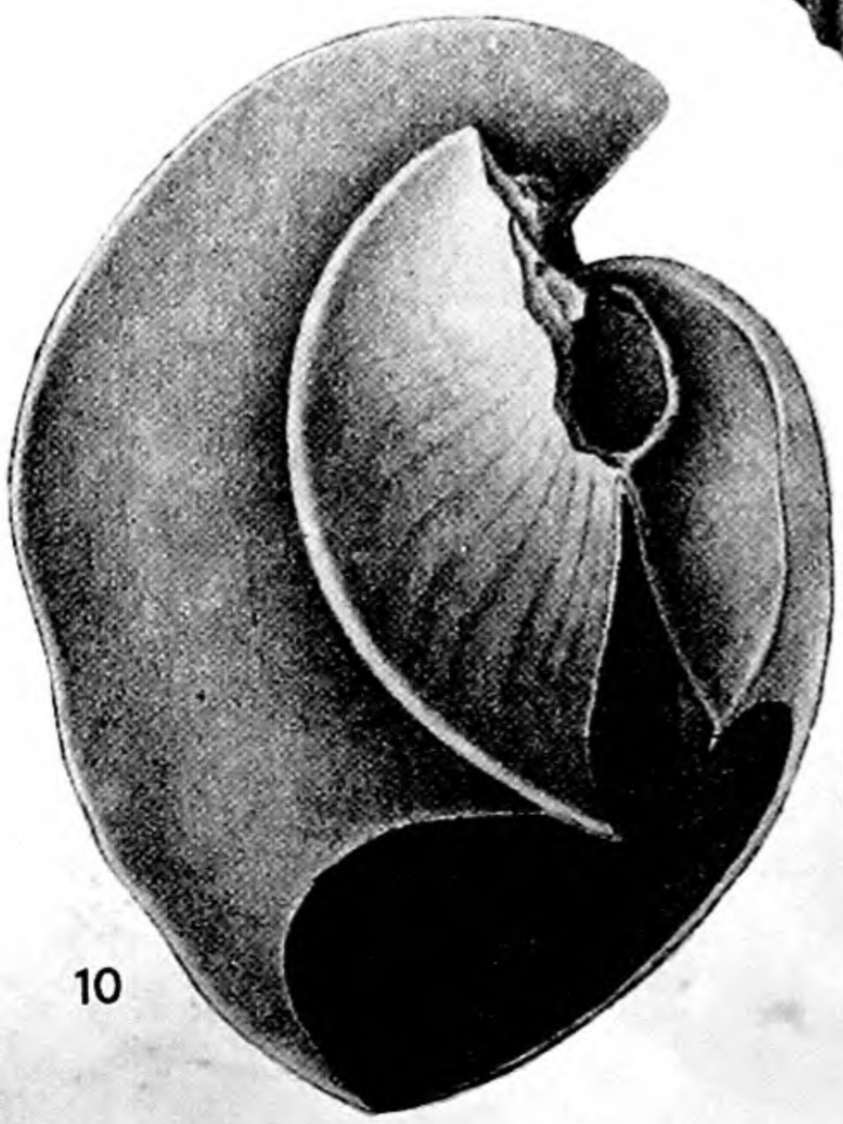

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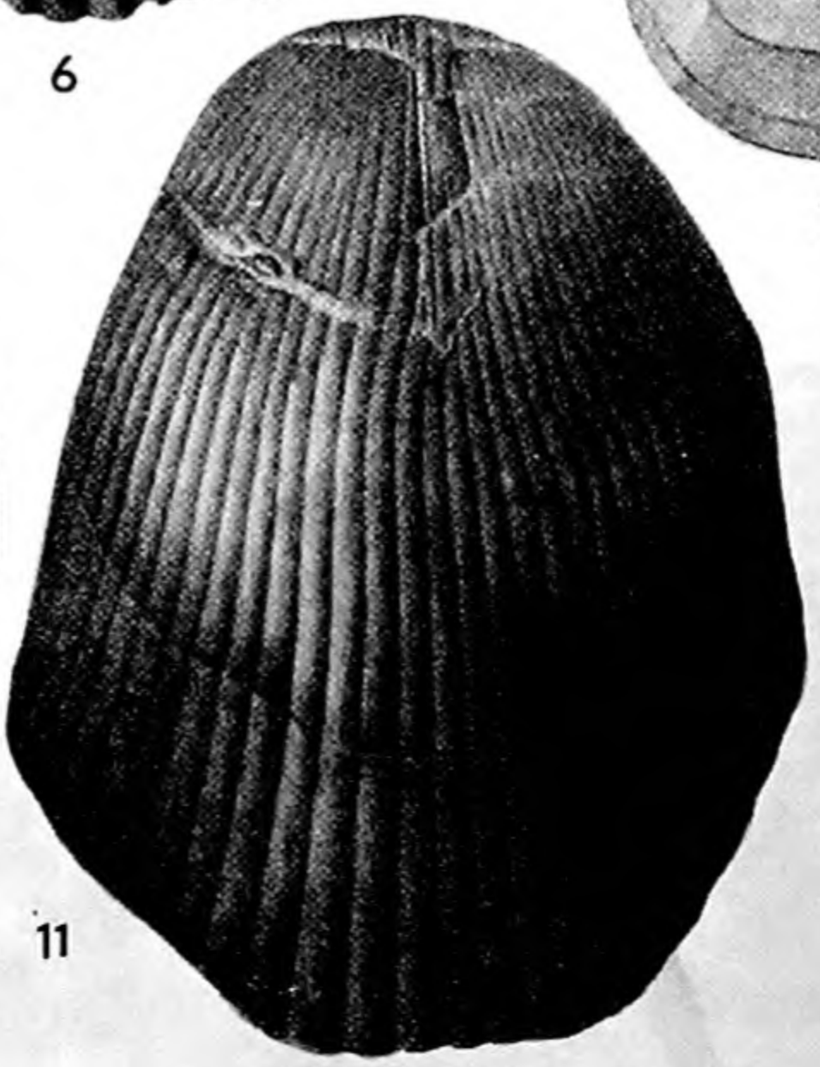

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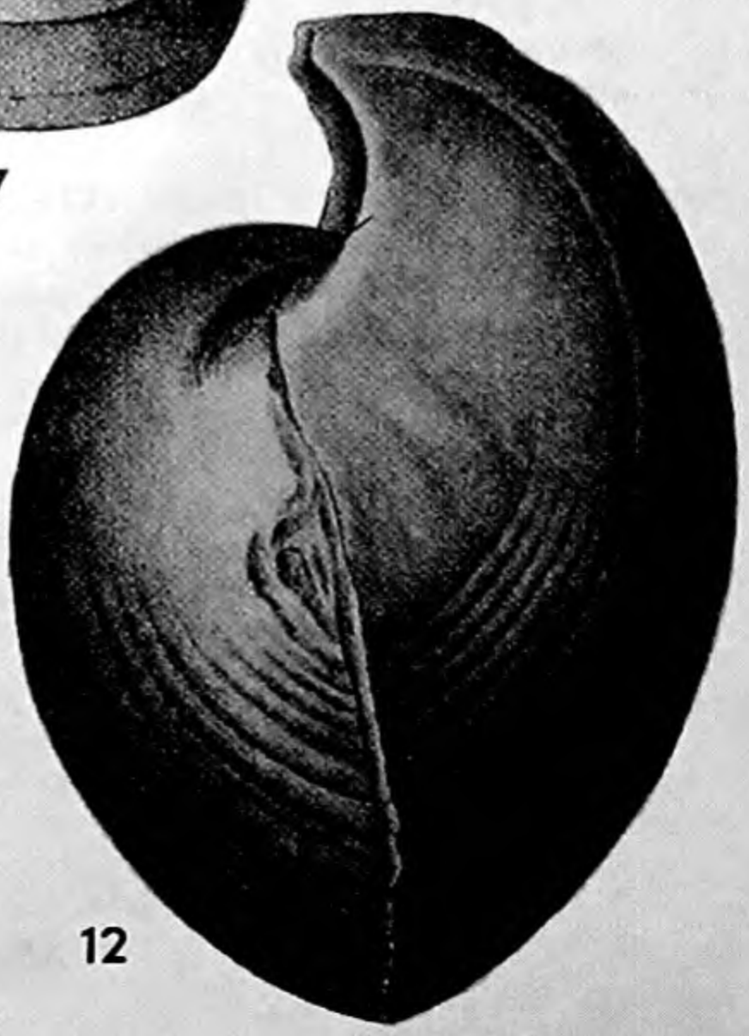

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VIRGIANA Twenhofel 1914

(**Pentamerus barrandei* Billings). Biconvex, elongate and with ventral fold; ventral beak arched over dorsal; spondylium with short septum; dorsal interior with two short, subparallel supporting plates. **M. Sil.** (Anticosti; Canada; Wis., Great Basin).

***V. barrandei** (Billings) (**115**—28). **Niagaran:** Anticosti (Becsie River).

V. decussata (Whiteaves) (**115**—25–27). Large, attaining a length of nearly 50 mm; surface costellate. **M. Sil.:** Mich., Wis.; Man., Sask.; Great Basin.

STRICKLANDIA Billings 1859

(**S. gaspiensis*). Aberrant, with elongate shells; biconvex, surface generally costate; ventral valve with low beak and spondylium; dorsal valve with a divided hinge plate and two long, straight brachial processes given off from inside of hinge plate. **M. Sil.** (N. B.; Que., Ont.; Appalachians, Mississippi Valley).

***S. gaspiensis** Billings (**117**—48). Large, 12.5 cm or more long, subelliptical to pentagonal in outline; anterior margin often with elongate median lobe; fold strong; valves multicostate. **M. Sil.:** Que.

S. triplesana Foerste (**117**—1–3). Approaching 50 mm in length, slightly longer than wide; hinge wide; fold low; surface nearly smooth. **M. Sil.** (Clinton): Ohio, Tenn.

S. castellana White (**117**—5, 6). Small, subcircular to longitudinally elliptical; surface strongly multicostate; fold low and narrow. **M. Sil.:** Ia.

TRIPLESIACEA. Impunctate Brachiopoda with flat pseudodeltidium and forked cardinal process.

OXOPLECIA Wilson 1913 (**105**—8)

(**O. calhouni*). Like *Triplesia* internally and externally but with fine costae or costellae crossed by closely spaced concentric elevated lines. **L. Ord.** to **M. Sil.** (Que., Ont.; Appalachians, Ark., Great Basin).

O. holstonensis Willard (**117**—4). Small, between 13 and 18 mm wide; sides narrowly rounded; fold low, wide; surface costellate. **M. Ord.** (Holston and Whitesburg): Va., E. Tenn.

O. gouldi Ulrich and Cooper (**117**—7–11). Large, over 25 mm in width, strongly costellate. **M. Ord.:** ?Va. (Chambersburg), ?Tenn. (Ottosee), Okla. (Bromide).

O. simulatrix (Bassler). **Chambersburg:** Appalachians.

TRIPLESIA Hall 1859

(**Atrypa extans*). Transversely elliptical in outline, biconvex; hinge narrow; pseudodeltidium flat and flush with palintrope; foramen small, apical; ventral interior with short dental plates; dorsal with short brachial processes and long forked cardinal process. **M. Ord.** to **M. Sil.** (Ont.; N. Y., Appalachians, Ohio, Ky., W. Tenn., Ark.).

T. cuspidata Clark (**117**—12–16). **M. Ord.** (L. Trenton): Ont.; N. Y.

T. ortoni (Meek) (**117**—17–21). 38 mm in length when full grown, longer than wide, longitudinally rectangular in outline; sulcus and fold broad. **L. Sil.** (Brassfield): Ohio, Ind., Ky., W. Tenn., Ark.

DICTYONELLA Hall 1867

(**Rhynchonella? reticulata*). Small, biconvex, rostrate with subtriangular outline; exterior punctate, the pits defined by a fine network of elevated lines; ventral valve with large foramen anterior to apex; dorsal valve with median septum rising to a sharp point at middle. **M. Sil.** (Que.; Ind., W. Tenn., Okla.). [Taxonomic position uncertain.]

***D. reticulata** (Hall) (**117**—22–24). Niagaran (Waldron): Ind., W. Tenn.

RHYNCHONELLACEA. Subtriangular, rostrate, generally costate, with delthyrium usually closed by deltidial plates; foramen located just anterior to beak; lophophore supported by crura.

ANCISTRORHYNCHA Ulrich and Cooper 1942

(**A. costata*). Small, biconvex, subtriangular to subcircular, costellate-costate; anterior commissure gently uniplicate; delthyrium open; interarea vestigial; dental plates well developed; dorsal interior with divided hinge plate; long slender crura with anterolaterally directed hooklike expansion at its free end; no median spetum. **M. Ord.** (Ridley–Lowville) (Appalachians; Sequatchie Valley; Central Basin of Tenn., Mississippi Valley, Arbuckle Mts, Ark.).

***A. costata** U and C (= **Protorhyncha ridleyana** Safford) (**117**—30–33). **M. Ord.:** Tenn. (Ridley).

ROSTRICELLULA Ulrich and Cooper 1942

(**R. rostrata*). Subtriangular to subpentagonal in outline; dorsal deeper than ventral valve; delthyrium partly restricted by rudimentary deltidial plates; ventral dental plates strong; dorsal interior with divided hinge plate united to strong median septum by supporting plates to form a short cruralium; no

PLATE 116

[All figures are x1 and after Hall and Clarke [Pal N Y 8 (1)] unless otherwise indicated.]

1. Pentamerus sp. [original]. Post view of a complete Int F showing impressions of the several plates and septa. **2–4. Pentamerus laevis.** D view showing trilobed surface and closely incurved and depressed V beak; V and D exts of a subquadrate shell with distinct surface lobation. **5. Conchidium knighti.** S view of an average typical specimen from England [H and C, after Davidson]. **6. Conchidium laqueatum.** D view of an Int F of a narrow specimen. **7. Pentamerus cylindricus.** D ext of a typical specimen. **8, 9. Pentamerus laevis.** D view of an Int F of a small shell; longitudinal section showing short median septum and septal plates, spondylium, and crural processes. **10–12. Conchidium laqueatum.** Longitudinal section; V and S views.

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cardinal process. **M. Ord.** (Que., Ont.; N. Y., Appalachians, Mississippi Valley, W.Tenn., Okla.).

R. plena Hall (**117**—25–29). Fairly large, length up to 19 mm; ventral valve moderately convex; dorsal valve strongly convex, sulcus with five to seven costae, flanks with up to nine costae. **M. Ord.** (Chazy [Valcour]): Que.; Lake Champlain area; Ottawa Valley.

***R. rostrata** U and C (**117**—34–40). Subpentagonal in outline, widest slightly anterior to middle; sulcus with three or four costae; fold with four or five; flanks with six costae. **M. Ord.** (Lebanon): Appalachians.

R. ainsliei (Winchell) (**118**—1–3). **M. Ord.** (Black River): Ont.; U. Mississippi Valley.

RHYNCHOTREMA Hall 1860 (118—17, 18)

(**Rhynchonella increbescens*). Costate, lamellose, uniplicate; ventral delthyrium generally covered with concave deltidial plates; muscular area large; dorsal valve with thick median septum, simple ridgelike cardinal process and divided hinge plate supported by short plates attached to median septum and forming a short cruralium. **M.** and **U. Ord.** (Trenton through Richmond) (all areas of these sediments).

***R. increbescens** (Hall) (**118**—14–16). Subtriangular in outline, small, about 13 mm wide; surface marked by about 16 costae, 3 in sulcus and 4 on fold. **M. Ord.** (Trenton): Ont.; N. Y., Appalachians, Mississippi Valley.

R. argenturbicum (White) (**118**—4–6). Small, subtriangular, widest anteriorly; three costae in sulcus; four costae forming a narrowly rounded fold; flanks with six costae. **U. Ord.:** Tex., N. Mex. (Montoya).

R. minnesotense Sardeson (**118**—19–22). Small, globose, with 12 to 14 costae; 3 or 4 in sulcus. **M. Ord.** (Black River): N. Y., Mississippi Valley.

R. capax (Conrad) (**118**—7–10). Large, attaining a width of about 19 mm; fold low, with four costae; dorsal valve more convex than the ventral but both often tumid; lamellae strong, closely crowded. **U. Ord.** (Richmond): Ohio, Ind., Ky., (related forms in Hudson Bay area; Tenn., Wis., Ill., Mo., Okla.; Man.).

R. dentatum Hall (**118**—11–13). Small, subtriangular in outline with one costa in sulcus and two on fold. **U. Ord.** (Richmond): Ohio, Ind., Ky., W. Tenn.

R. perlamellosum Whitfield (**118**—29, 30). Not so ventricose as *R. capax* but more strongly lamellose **U. Ord.** (Maquoketa): Wis., Ill., Minn., Ia.

ORTHORHYNCHULA Hall and Clarke 1893

(**Orthis linneyi* James). Triangular in outline, costate; hinge narrow, interarea rudimentary; ventral interior with rudimentary dental plates; dorsal valve with simple cardinal process. **M. Ord.** (Appalachians, Ohio Valley, Tenn.).

***O. linneyi** (James) (**117**—41–47). **Maysville:** Tenn., Ohio Valley.

O. stevensoni (Grabau). **Martinsburg:** Appalachians.

RHYNCHOTRETA Hall 1879

(**Terebratula cuneata* Dalman). Elongate, triangular; beak erect, foramen apical, covered with deltidial plates; ventral interior with long dental plates; dorsal valve with long curved crura and median septum. **Sil.** (N. B., Que.; N. Y., Appalachians, Ohio, Ind., Ky., Tenn., Wis., Ill., Mo., Okla.).

R. americana Hall (**118**—23–25). Small, cuneate, with elongated beaks, the ventral beak very slender; dorsal umbo deeply sulcate, sulcus passing into a subangular fold anteriorly; fold formed of four costae, the two median ones elevated, the lateral two depressed; sulcus deep, occupied by three costae; flanks marked by three costae. **M. Sil.:** Ont.; N. Y., Ind., Ky., W. Tenn., Wis.

STEGERHYNCHUS Foerste 1909

(**Rhynchonella whitii praecursor*). Externally like *Camarotoechia* but interior with thin lamellar cardinal process. **M. Sil.** (Ind., Tenn., Wis., Mo., Okla.).

S. whitii (Hall) (**118**—31–33). Small, about 13 mm wide; subpentagonal in outline with narrowly rounded sides and narrow, high fold composed of two costae; one costa in sulcus, six on flanks. **M. Sil.** (Waldron): Ind., W. Tenn.

S. neglectum (Hall) (**118**—38–40). Small, subtriangular in outline, slightly more than 7 mm in width, sulcus with three costae, flanks with six. **M. Sil.:** N. Y., Ind.

S. indianense (Hall) (**118**—26–28). **Niagaran:** N. Y., Ind., Ky., Tenn., Wis.

S. acinus (Hall) (**118**—34–37). Very small, generally less than 7 mm wide, sulcus with one or two costae; outline longitudinally, narrowly oval; valves nearly equal in depth. **M. Sil.** (Waldron): Ind., Ky., W. Tenn.

PLATE 117

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Stricklandia triplesana. V, D, and Post views of an Int F. **4. Oxoplecia holstonensis.** V ext. **5, 6. Stricklandia castellana.** V and D exts. **7–11. Oxoplecia gouldi.** Post, V, and D views; Post view of int (x2); ornamentation (x3). **12–21. Triplesia spp. 12–16. T. cuspidata.** S, D, V, Ant, and Post views. **17–21. T. ortoni.** Ant and Post views of cardinal process; S, V, and D views. **22–24. Dictyonella reticulata.** Dv (x1, x2); Vv (x3). **25–29. Rostricellula plena.** V, D, S, Ant, and Post views of one of Hall's types. **30–33. Anclstrorhyncha costata.** D exts (x1, x2); D int showing crura (x4). **34–40. Rostricellula rostrata.** 34: D int showing long crus and cruralium (x4); Posterodorsal view showing open delthyrium (x3); 36: V int (x2); 37, 39, 40: D, Ant, and S views; 38: Fine ornamentation (x6). **41–47. Orthorhynchula linneyi.** D int; V ext; Post view; D ext; S view; two D ints (x2). **48. Stricklandia gaspiensis** [Pal N Y 8 (2)]. D view.

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EATONIA Hall 1857

(**Atrypa medialis* Vanuxem). Subcircular in outline, costate, uniplicate; ventral valve shallower than dorsal; dental plates absent; muscular field large and flabellate; dorsal interior having large cardinal process with erect shaft resting on median septum and with myophore long and divided into two branches extending into the ventral valve; crura long and slender. **L. Dev.** (Que.; N. Y., Appalachians, W. Tenn., Okla.).

***E. medialis** (Hall) (**118**—41–43). **L. Dev.:** Que.; Me., N. Y., Appalachians.

COSTELLIROSTRA Cooper 1942

(**Atrypa peculiaris* Conrad). Medium-sized to large; dorsal valve the larger; outline elongate oval to subtriangular; surface multicostellate; ventral valve with short concave deltidial plates; teeth cemented to wall of valve by callus; muscular field large, diductors flabellate; adductors attached to bottom of a covered pit; dorsal valve with ponderous cardinal process having two elongate lateral prongs. **Dev.** (Oriskany to Onondaga) (Que., Ont.; N. Y., Appalachians, W. Tenn., Mississippi Valley, Okla.).

***C. peculiaris** (Conrad) (**118**—44–48). Same range and distribution as genus.

CAMAROTOECHIA
Hall and Clarke 1893 (**118**—49)

(**Atrypa congregata* Conrad). Generally triangular, costate, uniplicate, with shallow ventral valve and strongly convex dorsal valve; ventral interior with well developed dental plate; dorsal interior with divided hinge plates; no cardinal process, and segments of hinge plate attached to median septum by supporting plates making a short, small cruralium often covered with growth of inner hinge plates. **Sil.?–M. Miss.** (all areas of outcrop).

***C. congregata** (Conrad) (**118**—50–53). Small, 13 to 19 mm wide; outline oval to subtriangular; sulcus with three or four costae; fold with four or five. **M. Dev.** (Hamilton): N. Y., Pa., Ind.

C. sappho (Hall) (**118**—57–61). Large, attaining width of 25 mm; transverse; four to six costae in sulcus. **M. Dev.** (Hamilton): N. Y.

C. contracta (Hall) (**118**—54–56). Small, 13 to 19 mm wide, outline transversely subelliptical; sulcus with three costae. **U. Dev.** (Chemung): N. Y., Appalachians, Great Basin, southwestern U. S. A.

C. mutata (Hall) (**118**—62–65). Small, less than 13 mm wide, subtriangular in outline; four to six costae in sulcus. **Miss.** (Salem): Ind., Ill.

ALLORHYNCHUS Weller 1910

(**Rhynchonella heteropsis* Winchell). Like *Camarotoechia* but without dental plates. **Miss.** (Mississippi Valley).

***A. heteropsis** (Winchell) (**118**—66–68). **Miss.:** Mississippi Valley.

CALLIPLEURA Cooper 1942
(= CYCLORHINA Hall and Clarke 1893)

(**Rhynchospira nobilis* Hall). Generally large rhynchonellids with large circular foramen; costate, with row of nodes on costae; uniplicate; ventral interior with large pedicle callist and elongate muscular field; dorsal interior with divided hinge plate. **Dev.** (Hamilton) (Ont.; N. Y., Mich., Ohio, Ind., Ky.).

***C. nobilis** (Hall) (**118**—69, 70). Range and distribution same as genus.

PLETHORHYNCHA Hall and Clarke 1893

(**Rhynchonella speciosa* Hall). Large; ventral valve slightly less deep than dorsal, costate; fold and sulcus poorly developed; dorsal interior with median septum, much thickened hinge plate bearing a bilobed cardinal process and short straight crura. **Dev.** (Oriskany) (Que., Ont.; N. Y., Appalachians, Ill., W. Tenn., Mo., Okla.).

***P. speciosa** (Hall) (**118**—71–74). Range and distribution same as genus.

PARYPHORHYNCHUS Weller 1905

(**P. elongatum*). Medium to large size; uniplicate; triangular to elongate triangular in outline; costate but with entire surface covered with fine radiating lines; internally like *Camarotoechia*. **L. Miss.** (N. Y., Pa., Mississippi Valley).

P. striaticostatum (Meek and Worthen) (**119**—1–3). Wider than long, medium sized; wide ventral sulcus and low broad dorsal fold. **Kinderhook:** Ill., Ia.

P. transversum Weller. **Kinderhook:** Mississippi Valley.

LEIORHYNCHUS Hall 1860

(**Orthis quadricostata* Vanuxem). Moderate to large size; triangular to subcircular; costate but often

PLATE 118

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Rostricellula ainsliei. V, D, and S views. **4–22. Rhynchotrema** spp. **4–6. R. argenturbicum.** V, S, and D views. **7–10. R. capax.** S, V, and D views; S view of an obese specimen. **11–13. R. dentatum.** V, D, and S views. **14–16. R. increbescens.** D, V, and S views. **17, 18. R. sp.** D and V ints (x2). **19–22. R. minnesotense.** V, D, D, and S views of two specimens. **23–25. Rhynchotreta americana.** V, D, and S views. **26–28. Stegerhynchus indianense.** V, D, and S views. **29, 30. Rhynchotrema perlamellosum.** V and S views. **31–40. Stegerhynchus** spp. **31–33. S. whitei.** V, D, and S views. **34–37. S. acinus.** D ext; D, V, and S views (x2). **38–40. S. neglectum.** V, D, and S views. **41–43. Eatonia medialis.** V, D, and S views. **44–48. Costellirostra peculiaris.** Two D ints; V int; D int and ext. **49–65. Camarotoechia** spp. **49. C. sp.** Int showing cruralium (x2). **50–53. C. congregata** [Pal N Y 8 (2)]. V, D, S, and Ant views. **54–56. C. contracta** [Pal N Y 8 (2)]. V, Ant, and D views. **57–61. C. sappho.** V, D, Ant, and S views [Pal N Y 8 (2)]; D ext. **62–65. C. mutata** [Ill G S, M 1]. V, D, Ant, and S views. **66–68. Allorhynchus heteropsis** [Ill G S, M 1]. Ant, D, and V views. **69, 70. Callipleura nobilis.** V int; D ext. **71–74. Plethorhyncha speciosa** [Pal N Y 8 (2)]. S view; D int; Post view; V int.

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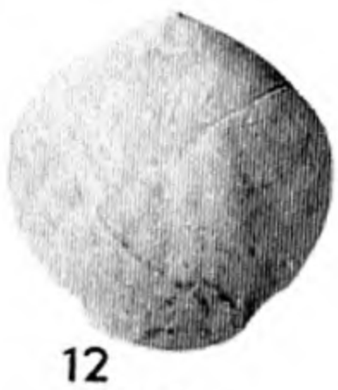
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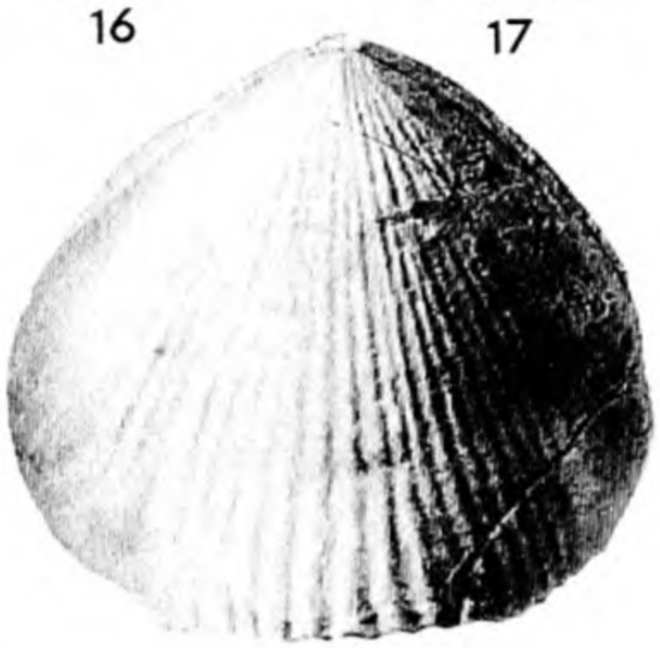
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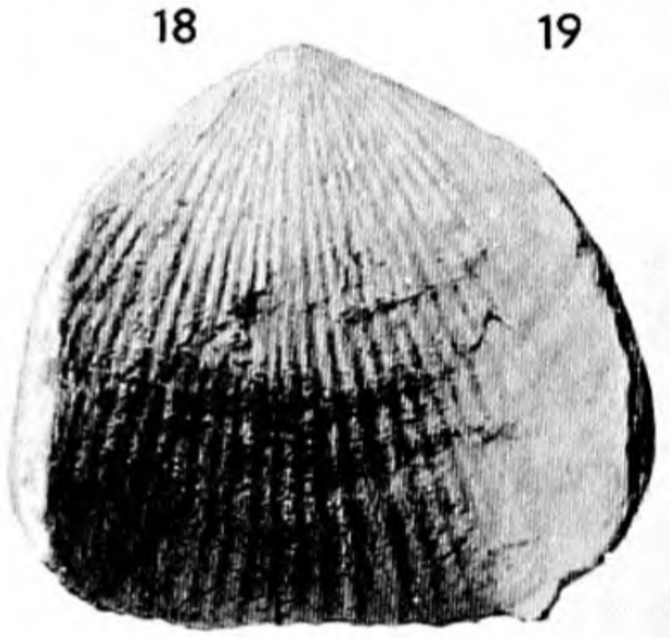
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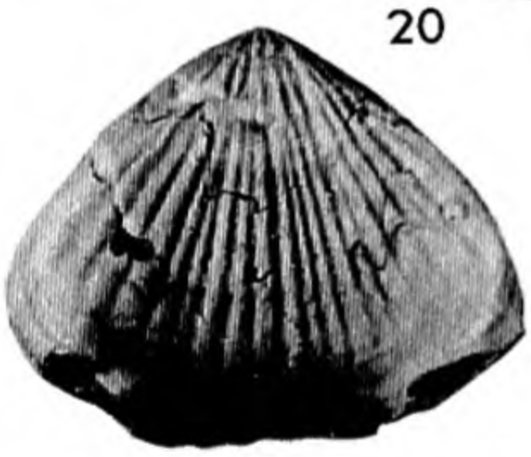
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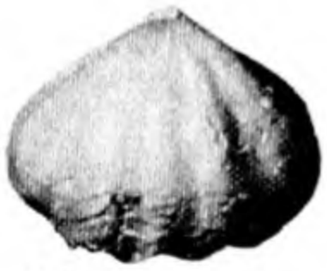
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with flanks smooth or only partly costate; costae often bifurcated (a rare condition in rhynchonellids); uniplicate; dental plates reduced; median septum low, adductor field narrowly and longitudinally elliptical. **M. Dev.–Penn.** (all areas of outcrop).

L. limitare (Vanuxem) (**119**—42). Small, about 13 mm in width; outline usually subcircular; sulcus and flanks strongly costellate; generally flattened in shale. **M. Dev.** (Marcellus-Skaneateles?) (Ont.; N. Y., Pa., Md., Va., W. Va., Ohio, Ill.).

L. multicostum (Hall) (**119**—8, 9). Large, slightly over 25 mm in width; strong fold and sulcus; subcircular outline; strongly ornamented flanks and fold. **M. Dev.** (Hamilton): Ont.; N. Y., Pa.

L. laura (Billings) (**119**—5–7). About 25 mm wide, elongate triangular in outline; fold and sulcus more strongly costate than flanks. **M. Dev.** (Hamilton–Widder): Ont.

L. mesacostale (Hall) (**119**—4). Resembling *L. multicostum* but smaller and more finely costate. **Dev.** (Hamilton–Chemung): N. Y., Pa., Md., W. Va.

L. castaneum Meek (**119**—10–13). Large, slightly more than 25 mm wide; dorsal valve gibbous, ventral valve gently convex; outline subcircular; fold and sulcus more or less distinctly costate; posterior smooth, sides smooth or faintly costate. **M. Dev.:** Nev. (Nevada); Canadian Rockies; Mackenzie Valley.

L. carboniferum Girty (**119**—14–16). Large, about 25 mm wide, outline subtriangular; fold and sulcus narrow, only faintly costate; flanks smooth or faintly costate. **Miss.:** Ark. (Moorefield), Okla., Mont., Nev.

L. rockymontanum (Marcou) (**119**—17–19). Large, about 25 mm wide; sulcus wide, occupied by two to four costae; flanks smooth. **Penn.** (Mainly Des Moines): Neb., Kan., Mo., Okla., Tex.

PAURORHYNCHA Cooper 1942

(**Camarotoechia endlichi* Meek). Large, resembling *Leiorhynchus* externally but very deeply sulcate and with small beak; interior with small oval ventral muscular area, dorsal hinge plate divided and supported by a strong median septum. **U. Dev.**

***P. endlichi** (Meek) (**119**—20–22). Large, multicostate, with sulcus and fold occupying nearly entire anterior part; flanks narrow, concave on ventral valve. **U. Dev.** (Ouray): Colo., Ariz. (A related species in the Percha shale of N. Mex.)

P. sp. (**119**—23–26). **U. Dev.:** Colo., N. Mex.

SHUMARDELLA Weller 1910

(**Rhynchonella missouriensis* Shumard). Rhynchonelliform, strong fold and sulcus, costae nearly obsolete as in *Leiorhynchus*; strong dental plates in ventral valve; dorsal interior with median septum, small cruralium and divided hinge plate. **Miss.** (Pa., Ia., Mo.).

***S. missouriensis** (Shumard) (**119**—27–30). **Chouteau:** Mo.

UNCINULUS Bayle 1878

(**Terebratula subwilsoni* Orbigny). Circular or subcuboidal in outline and profile; dorsal valve usually having the greater depth, ventral tongue long; ventral interior with large deep, oval muscle scar having subflabellate diductor scars; dorsal cruralium small, crura long and slender. **Sil., L. Dev.** (Que.; eastern U. S. A., Mississippi Valley, Okla.).

U. saffordi Hall (**119**—31–34). Width and thickness about 13 mm; five or six costae in sulcus. **M. Sil.:** W. Tenn. (Brownsport).

U. ventricosus (Hall) (**119**—38–41). About 16 mm wide, both valves very deep producing a shell having the thickness as its greatest dimension; sulcus shallow, fold slightly developed and formed of three or four costae. **L. Dev.** (Becraft): N. Y., Pa., Appalachians.

U. nucleolatus (Hall) (**119**—35–37). Pentagonal in outline; strongly inequivalved, the dorsal very deep; sulcus shallow but with long tongue having three to five costae; fold low. **L. Dev.:** N. B.; Me. N. Y. (New Scotland), Appalachians, W. Tenn., Okla., Mo.

TRIGONIRHYNCHIA Cooper 1942

(= UNCINULINA Bayle 1878)

(**Uncinulina fallaciosa* Bayle). Large, subtrigonal in outline, biconvex in profile; dorsal valve deeper than ventral; beak small, incurved. **M. Sil., L. Dev.** (Ind., Ky., W. Tenn., Wis.).

T. sulcata Cooper (**120**—10–12). Large, 31 mm wide, with broad shallow sulcus containing six to nine costae, and low, broad fold. **M. Sil.** (Waldron): Ind., W. Tenn.

T. tennesseensis (Foerste) (**120**—8, 9). About half the size of the preceding, with sulcus containing five costae. **M. Sil.:** W. Tenn. (Brownsport), Okla.

HYPOTHYRIDINA Buckman 1906

(**Atrypa cuboides* Sowerby). Subcuboidal in outline and globular in profile, ventral valve less deep than dorsal, and with long anterior tongue; costae low and rounded, separated by narrow striae; ventral interior with very short dental plates and small mus-

PLATE 119

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Paryphorhynchus striaticostatum [Ill G S, M 1]. V, D, and S views. **4–19. Leiorhynchus** spp. **4. L. mesacostale.** D view of Int F. **5–7. L. laura.** V, D, and S views. **8, 9. L. multicostatum.** D and Post views of Int F. **10–13. L. castaneum.** Ant, V, D, and S views. **14–16. L. carboniferum.** V, D, and S views. **17–19. L. rockymontanum.** V, D, and S views. **20–26. Paurorhyncha** spp. **20–22. P. endlichi.** V view of Int F; D and V exts [USGS, B 391]. **23–26. P.** sp. V, D, S, and Post views of an Int F. **27–30. Shumardella missouriensis** [Ill G S, M 1]. V, D, S, and Ant views. **31–41. Uncinulus** spp. **31–34. U. saffordi.** V, D, S, and Ant views. **35–37. U. nucleolatus.** V, D, and S views. **38–41. U. ventricosus.** D, Post, S, and Ant views. **42. Leiorhynchus limitare.** Black shale showing numerous specimens.

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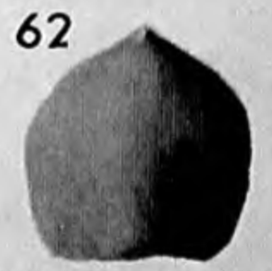
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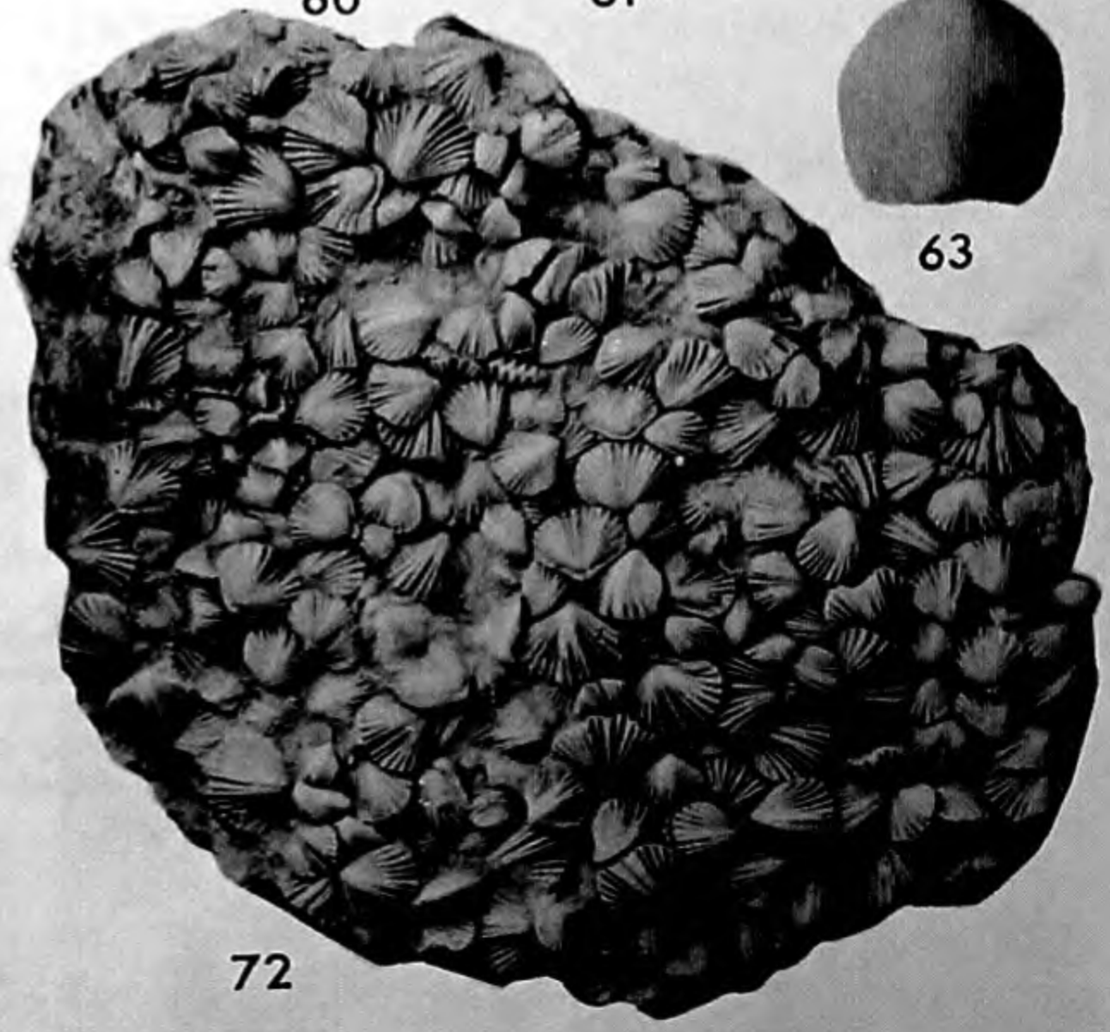
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cular field; dorsal interior without a median septum. **M. to U. Dev.** (Tully to Chemung) (Hudson Bay; Mackenzie Valley; N. Y., Pa., Ky., Ia., Mo., Nev.).

H. venustula (Hall) (**120**—5–7). Large, about 25 mm wide, slightly elliptical in transverse outline; sulcus with 4 to 14 costae. **M. Dev.** (Tully): N. Y., Pa., Ky.

H. emmonsi (Hall and Whitfield) (**120**—1–4). About same size as preceding but more transverse, shorter, and with more pronounced shoulder. **U. Dev.:** Mackenzie Valley; Nev.

PUGNOIDES Weller 1910

(**Rhynchonella ottumwa* White). Internally like *Camarotoechia* but with strong fold and sulcus and anterior marked by a few strong costae. **U. Dev.** to **Miss**. (N. Y., Appalachians, Mississippi Valley, Great Basin; western Canada).

P. calvini Fenton and Fenton (**120**—13–17). About 13 mm wide, subpentagonal in outline; ventral tongue long; fold high, subacuminate; sulcus with two to three costae, flanks with two to three short costae. **U. Dev.:** Ia. (Hackberry).

P. duplicatus (Hall) (**120**—18–21). About 13 mm wide; sulcus usually with one costa, rarely two; flanks marked by three costae of unequal size. **U. Dev.** (Chemung): N. Y., Pa., Md., Va.

***P. ottumwa** (White) (**120**—22–26). Small, usually wider than long, with width about 9 mm; fold low, sulcus with two or three, occasionally four or five costae; two or three costae on flanks. **Miss.** (Ste. Genevieve): Ill., Ia.

WELLERELLA Dunbar and Conrad 1932

(**W. tetrahedra*). Small shells externally resembling *Pugnoides*, internally with strong dental plates in ventral valve; dorsal valve with undivided hinge plate supported by a short median septum. **Penn., Perm.** (Midcontinent region, Tex., and southwestern U. S. A.).

W. immatura Dunbar and Condra (**120**—30, 31). Small, triangular, about 6 mm wide; suggesting *W. osagensis* but with plications originating 3 mm anterior to beak, and relatively wider. **Penn.** (Kansas City and Lansing groups): Kan., Neb.

W. osagensis (Swallow) (**120**—27–29). Subtriangular in outline, slightly less than 12 mm wide; sulcus with two costae; fold and flanks with three costae. **Penn.** (Shawnee and Wabaunsee groups): Kan., Neb.

W. delicatula Dunbar and Condra (**120**—32–34). About 6 mm in width, subcircular in outline, narrowly lenticular in profile; sulcus with two costae, fold with three, and flanks with three. **L. Perm.:** Neb.

MOOREFIELDELLA Girty 1911

(**Rhynchonella eurekensis* Walcott). Internally resembling *Camarotoechia* but with exterior costellate. **Miss.** (Ark., Okla., Nev.).

***M. eurekensis** (Walcott) (**120**—35–37). **Miss.:** Ark. (Spring Creek), Okla. (Mayes), Nev.

STENOSCISMA Conrad 1839

(= CAMEROPHORIA King 1844)

(**Terebratula schlotheimii* Buch). Rhynchonelliform; costate; ventral interior with spondylium; dorsal interior with elongate cruralium and long slender crura. **Dev.–Perm.** (Ont.; N. Y., Mich., Mississippi Valley, Ark., Okla., Tex., Great Basin; Mexico).

S. kernahani Whiteaves (**120**—46–48). About 6 mm wide; subtrigonal in outline and profile; fold with three costae, sulcus with two. **M. Dev.:** N. Y. (Centerfield), Ohio, Ind., Ky.

S. explanata (McChesney) (**120**—41–45). About 9 mm wide, subtriangular to subcircular in outline; profile rounded; sulcus developed at front half and containing a single costa. **U. Miss.** (Chester): Ky., Ill., Ark., Okla.

S. venusta (Girty) (**120**—38–40). Triangular in outline; 25 mm or more wide; about 5 costae in sulcus, four to six costae on flanks. **Perm.** (Leonard–Word): W. Tex.

UNCINULOIDES King 1930

(**Rhynchonella guadalupae* Shumard). Triangular in outline, numerous closely crowded costae; anterior tongue long and flattened as in *Rhynchopora*; interior like *Stenoscisma*. **Perm.** (W. Tex.).

***U. guadalupensis** (Shumard) (**120**—49–51). **Perm.:** W. Tex. (U. Leonard).

PEREGRINELLA Oehlert 1887

(**Rhynchonella peregrina* Orbigny). Large, subcircular in outline; ventral valve deeper and more convex than dorsal; dental plates very short; hinge

PLATE 120

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–7. Hypothyridina spp. **1–4. H. emmonsi.** V, Ant, S, and D views of holotype. **5–7. H. venustula.** D, S, and Ant views. **8–12. Trigonirhynchia** spp. **8, 9. T. tennesseensis.** V and D exts. **10–12. T. sulcata.** S, V, and D views. **13–26. Pugnoides** spp. **13–17. P. calvini.** Post, Ant, D, V, and S views. **18–21. P. duplicatus** [Pal N Y 8 (2)]. V and D exts; D view of Int F; S view. **22–26. P. ottumwa** [Ill G S, M 1]. V, D, and Post views of a wide shell; V and D views of an elongate shell. **27–34. Wellerella** spp. **27–29. W. osagensis.** V, D, and S views. **30, 31. W. immatura.** D and S views. **32–34. W. delicatula.** D, V, and S views. **35–37. Moorefieldella eurekensis.** V, D, and S views. **38–48. Stenoscisma** spp. **38–40. S. venusta.** D and V ints; D ext. **41–45. S. explanata** [Ill G S, M 1]. V and two D exts; S and Ant views. **46–48. S. kernahani** (x2). V, D, and S views. **49–51. Uncinuloides guadalupensis.** D, S, and Ant views. **52, 53. Protozyga nicolleti** (x2). D and S views. **54, 55. Zygospira kentuckiensis.** S and D views. **56. Zygospira recurvirostris.** D ext. **57–59. Cyclospira bisulcata.** V, D, and S views. **60, 61. Catazyga headi.** D and S views. **62, 63. Atrypella shrocki.** S and D views. **64, 65. Peregrinella whitneyi.** S and D views. **66–68. Plectatrypa praemarginalis.** V, D, and S views. **69–71. Atrypa independensis.** S, V, and D views. **72. Zygospira modesta.** Small slab showing many specimens.

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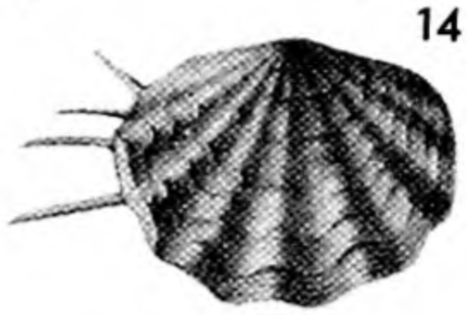
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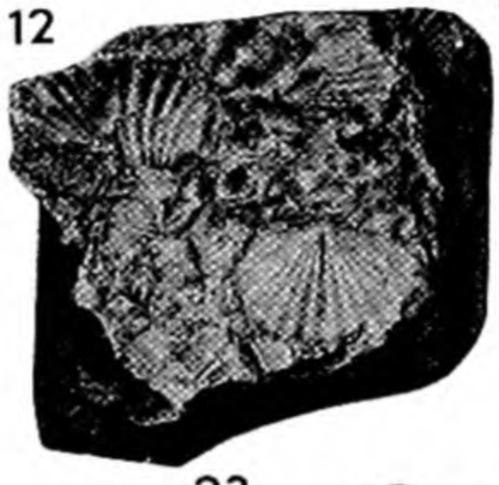
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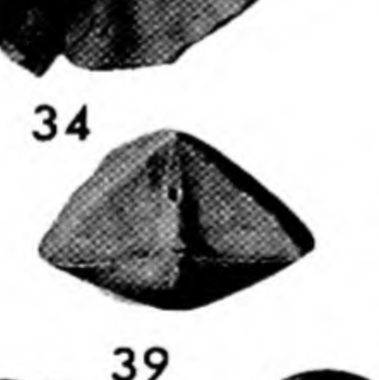
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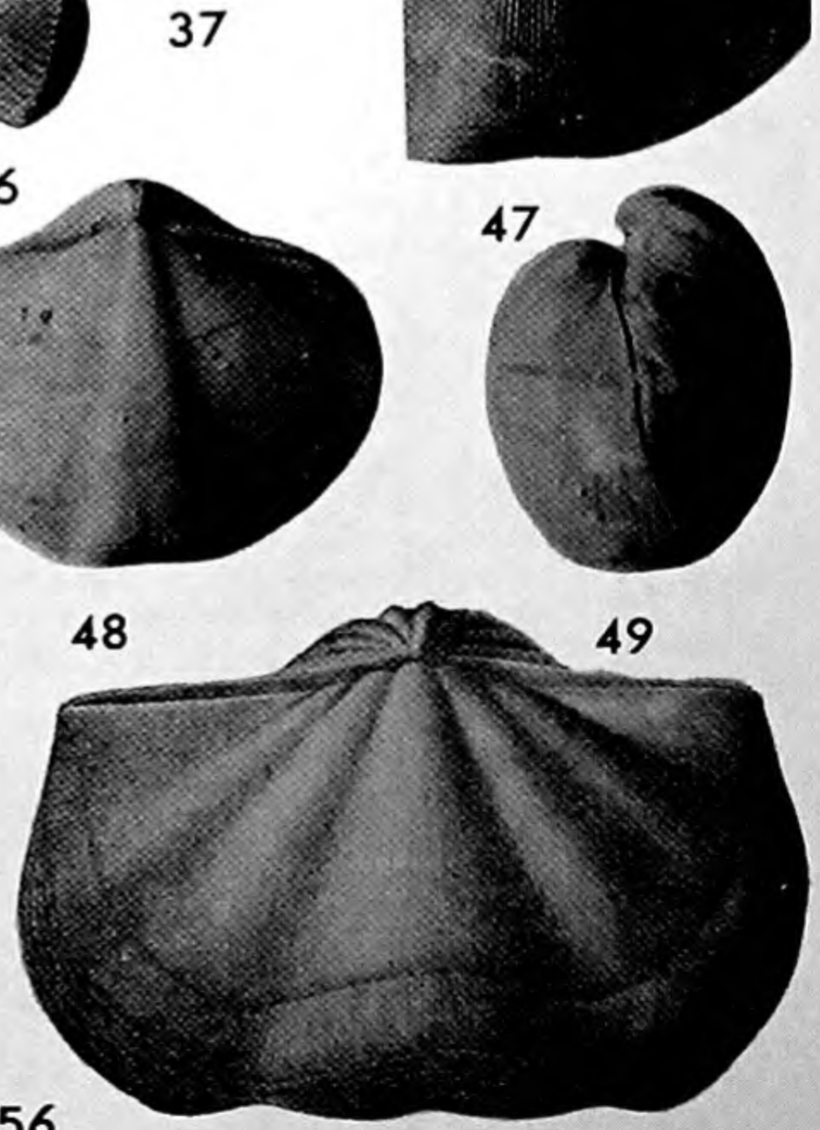
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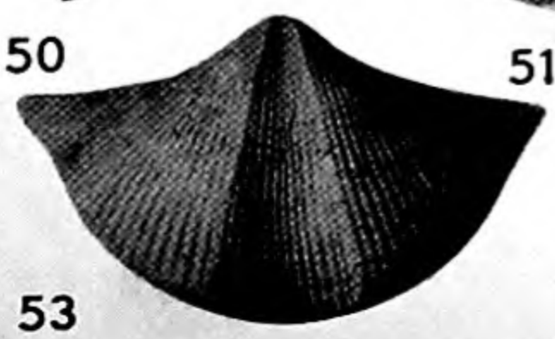
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plate supported by a long median septum. **Cret.** (Cal.; Europe).

P. whitneyi (Gabb) (**120**—64, 65). **Cret.:** Cal. (Knoxville).

SPIRIFERACEA. Articulata having lophophore supported by a spiral brachidium and delthyrium modified by pseudodeltidium or deltidial plates.

PROTOZYGA Hall and Clarke 1893

(**Atrypa exigua* Hall). Small, smooth or partly costate; valves unequally deep, the ventral one being the deeper; fold on ventral valve; delthyrium partly closed by rudimentary deltidial plates; ventral interior with dental plates; dorsal interior with divided hinge plate supporting a simple spire consisting of a single coil and joined by V-shaped jugum, the apex of which extends posteroventrally. **M. Ord.** (N. Y., Appalachians, Tenn., Mississippi Valley).

P. nicolleti Winchell and Schuchert (**120**—52, 53). Small, between four and six mm wide; dorsal fold prominent, flanks smooth or costate, costae numbering as many as five. **M. Ord.** (Black River–L. Trenton): Mississippi Valley; a related species occurs in Appalachians.

CYCLOSPIRA Hall 1893

(**Atrypa bisulcata* Emmons). Small, pentagonal in outline; biconvex in profile, the ventral valve very deep and subcarinate posteriorly but deeply sulcate anteriorly; dorsal sulcus with low fold corresponding to ventral sulcus; interior of ventral valve with thickened umbonal region; dorsal interior with small hinge plate supported by a median septum; brachidium delicate, of 2.5 to 3 coils slightly introverted; jugum unknown. **M. Ord.** (Whitesburg–Richmond) (widespread throughout eastern N. America).

***C. bisulcata** (Emmons) (**120**—57–59). **M. Ord.:** N. Y., U. Mississippi Valley.

ZYGOSPIRA Hall 1862

(**Atrypa modesta* Say). Externally like *Protozyga* with ventral fold and dorsal sulcus but with numerous strong costae; hinge plate divided, supporting spire with widely divergent descending lamellae and several coils directed medially; jugum simple, its position variable. **M. Ord.–L. Sil.** (Que., Ont.; N. Y., Appalachians, Ohio and Mississippi Valleys, Tenn., Okla.).

Z. recurvirostris (Hall) (**120**—56). Small, up to 7 mm wide, pentagonal to subcircular in outline; fold low, sulcus shallow; costae rounded. **M. Ord.** (Black River–Trenton): eastern half of U. S. A., Ottawa Valley.

***Z. modesta** (Say) (**120**—72). Differs from the preceding in its larger size, 7+ mm wide, wider and stronger sulcus, and stronger costae. **U. Ord.** (Maysville–Richmond): Que.; Appalachians, Ohio Valley, W. Tenn.

Z. kentuckiensis James (**120**—54, 55). Resembles *Z. modesta* but differs by its much larger size (over 13 mm). **U. Ord.:** Ky. (Richmond).

CATAZYGA Hall and Clarke 1893

(**Athyris headi* Billings). Large, globose in profile, subcircular to oval in outline; ventral valve with low fold; dorsal valve sulcate; ornamentation costate; ventral muscular area deeply impressed; dorsal valve with small divided hinge plate supporting a spire with inwardly wound coils; jugum posterior in position and directed inward posterior to apices of spire. **U. Ord.** (Richmond) (Anticosti; Que.; N. Y., Ohio Valley).

***C. headi** (Billings) (**120**—60, 61). **Richmond:** Que.; Ohio Valley.

PLECTATRYPA Schuchert and Cooper 1930

(**Atrypa imbricata* Sowerby). Valves subequally convex; dorsal valve with prominent fold; ventral valve with sulcus; spiral cones directed dorsally. **U. Ord.–M. Sil.** (Que.; Appalachians, Ohio, Tenn., Ill., Mo., Okla.).

P. praemarginalis Savage (**120**—66–68). Small, slightly wider than long (13 by 15 mm); beak long and incurved; valves subequally convex; ventral umbo convex, dorsal umbo sulcate; ventral fold passes into sulcus at about middle; fold narrow and low arising from the sulcus; fascicostate. **L. Sil.** (Edgewood): Ill., Mo.

P. "marginalis" type. Resembling the preceding but with somewhat wider and less fasciculate costae. **M. Sil.:** W. Tenn. (Brownsport), Okla.

ATRYPA Dalman 1828 (**106**—13)

(**Anomia reticularis* Linnaeus). Valves unequally convex, the ventral valve nearly flat or gently convex, the dorsal valve strongly convex; costellate to costate, lamellose to spinose, often frilled; ventral interior with large flabellate muscular field; dorsal

PLATE 121

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–18. Atrypa spp. **1–3. A. reticularis** [Pal N Y 4]. D, S, and Post views of a Devonian form assigned to this species. **4, 5. A. spinosa** [Pal N Y 4] S and V views. **6, 7. A. nevadana.** D and V views. **8, 9. A. elegans.** V and S views. **10–12. A. bellula** [JP 12]. S, V, and D views of holotype. **13. A. hystrix** [Pal N Y 4]. V view. **14, 15. A "reticularis"** [N Y St Mus, M 1]. V and S views of a Silurian form assigned to this species. **16–18. A. devoniana.** D, S, and V views. **19–25. Coelospira** spp. **19–21. C. concava** (x2). D ext; V and D ints. **22–25. C. hemisphaerica.** V and D exts; D int (x2); small slab with numerous specimens. **26–28. Leptocoelia flabellites.** D ext; D and V ints. **29. Atrypina disparilis.** D ext (x2). **30–32. Atrypina imbricata.** D ext and int (x2); D ext. **33–37. Pustulina pustulosa.** V ext and int (x2); D ext (x2); D ext (x3) showing pustules; D int (x2). **38–40. Cyrtia exporrecta.** D, Post, and S views. **41–46. Tenticospirifer** spp. **41–44. T. cyrtiniformis.** D, V, Post, and S views. **45, 46. T. utahensis.** D and S views. **47–49. Eospirifer radiatus.** Part of ext (x2) showing ornamentation; D and S views. **50, 51. Theodossia hungerfordi.** S and D views. **52. Cyrtospirifer monticola.** D ext. **53–55. Cyrtospirifer whitneyi.** V, D, and S views. **56. Eospirifer macropleurus** [Pal N Y 8 (2)]. D ext.

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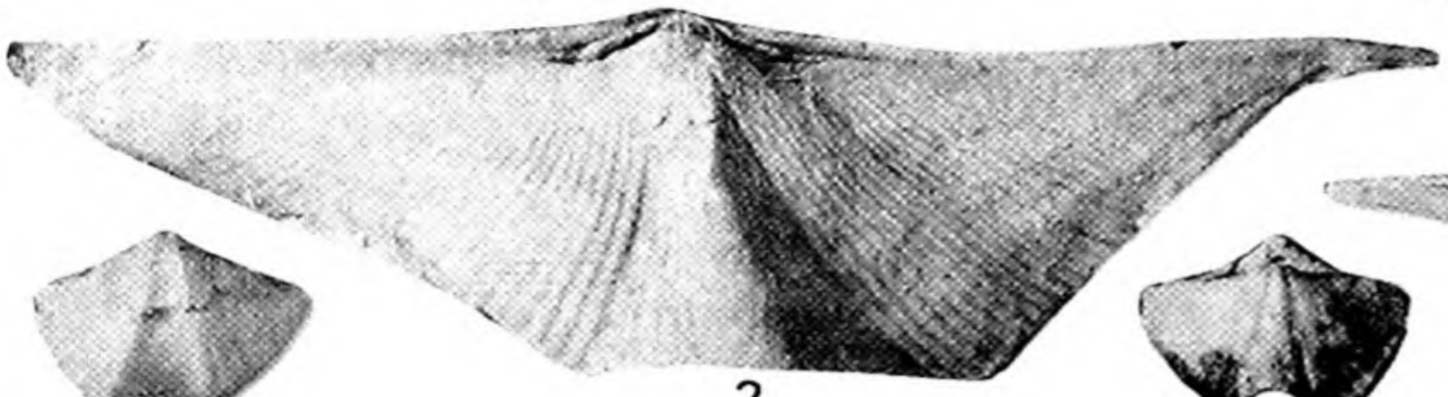
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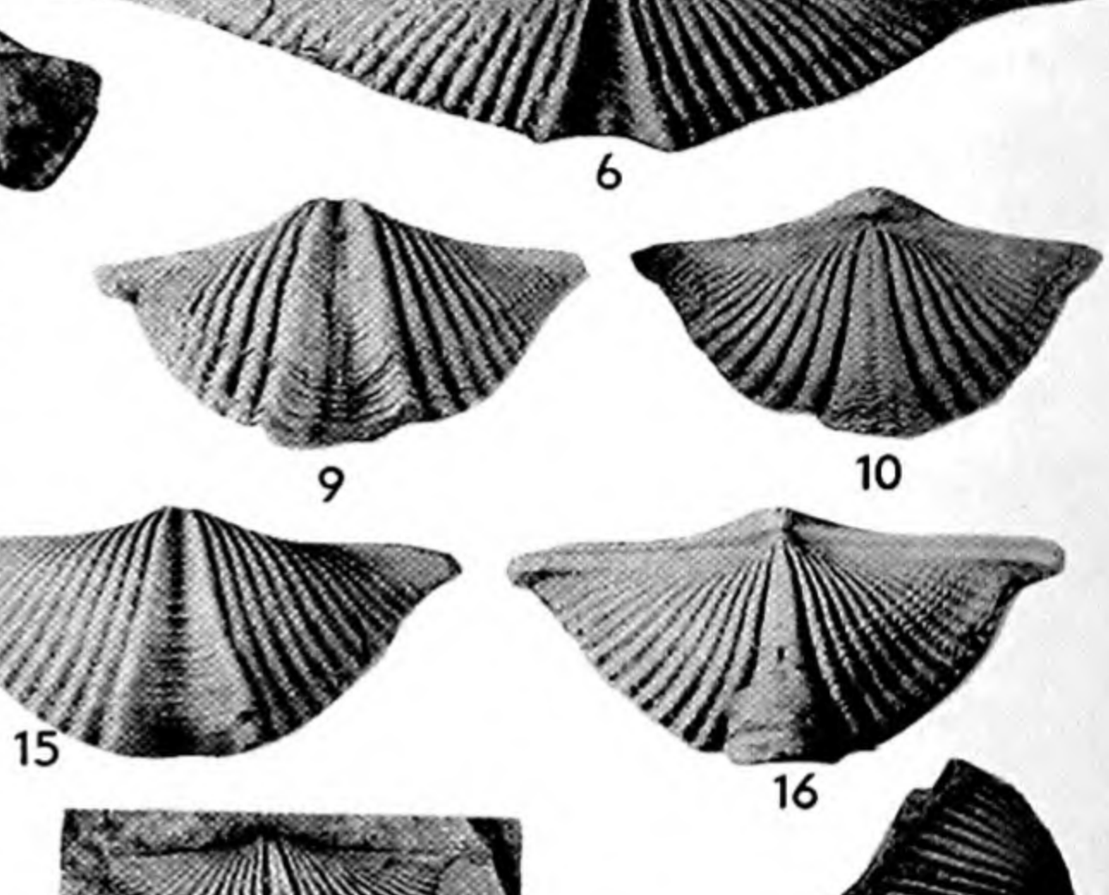
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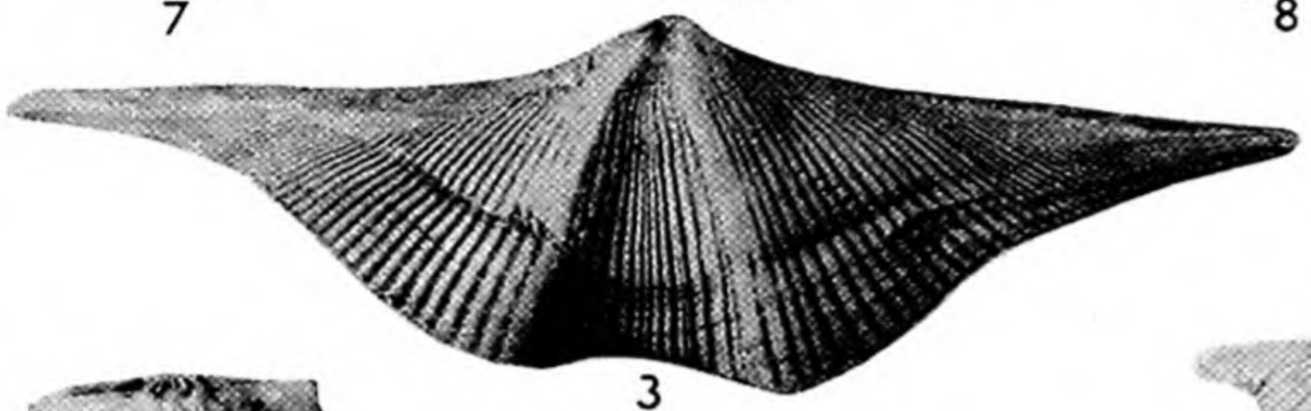
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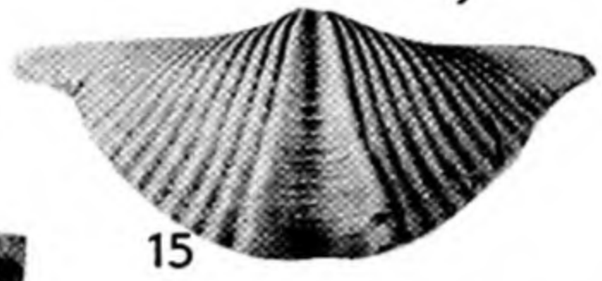
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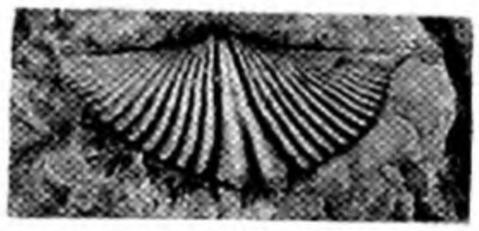
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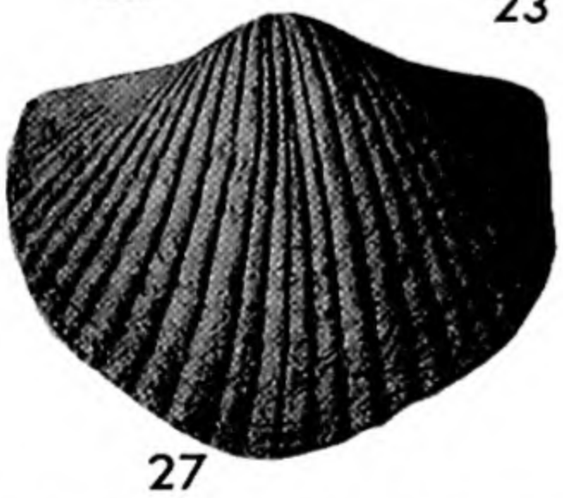
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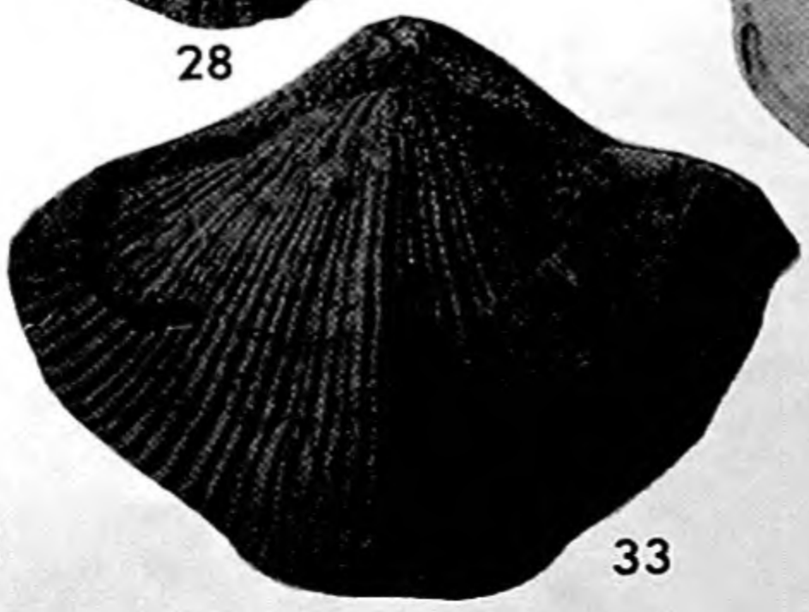
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interior with dorsally directed spiral cones, and widely divergent brachial supports. **M. Sil.–L. Miss.** (all areas of these rocks in U. S. A. and Canada).

***A. reticularis** (Linnaeus) (**121**—1–3) [**Dev.**]; 14, 15 [**Sil**]). Many unnamed species answering to the above generic description; the genotype is a European Silurian species. **Sil.–L. Dev.:** (In all areas of these rocks).

A. elegans Grabau (**121**—8, 9). Small, subcircular-suboval in outline, length and width about 18 mm; biconvex, but dorsal valve deeper than ventral; surface costellate. **M. Dev.:** Mich. (Dundee), Ohio (Delaware).

A. spinosa Hall (**121**—4, 5). Fairly large, subcircular to oval in outline; length and width about 38 mm; costate, strongest costae in middle, where there are eight in 13 mm; costae crossed by distant lamellae producing spines where lamellae and costae intersect. **M. Dev.** (Moscow): N. Y., Pa.

A. nevadana Merriam (**121**—6, 7). Subcircular in outline, width about 30 mm, length slightly less; ventral valve shallow, dorsal inflated; surface finely costate and with short lamellae; hinge equal to more than half greatest width. **L. Dev.:** Nev. (Nevada).

A. bellula Hall (**121**—10–12). **M. Dev.:** Ia. (Cedar Valley).

A. independensis Webster (**120**—69–71). Very large, subquadrate in outline, attaining a length and width of 57 mm; sides slightly curved, front subtruncate; dorsal valve with narrow anterior fold; frills often large. **M. Dev.:** Wis., Ia. (Cedar Valley).

A. hystrix Hall (**121**—13). Suggesting *A. spinosa* but with few costae and long spines. **U. Dev.** (Chemung): N. Y., Pa.

A. devoniana Webster (**121**—16–18). Elliptical with prominent posterior shoulders; longer (25 mm) than wide (21 mm); anterior narrowed into a rounded fold; surface finely costate. **U. Dev.:** Ia. (Hackberry).

ATRYPELLA Kozlowski 1929

(**Atrypa prunum* Dalman). Internally like *Atrypa* but with smooth exterior and subequally convex valves. **M.** and **U. Sil.** (Arctic; Ind.; S. E. Alaska).

A. shrocki Cooper (**120**—62, 63). **Niagaran:** Ind. (Huntington).

COELOSPIRA Hall 1863

(**Leptocoelia concava*). Small, concavo-convex; ventral valve with fold; dorsal valve sulcate; costate; ventral interior without dental plates; dorsal interior with large faintly bilobed cardinal process; median ridge present; crura short, joining primary lamellae at an acute angle; spires coiled laterally; jugum simple, extended ventrally as a long process. **M. Sil.** to **M. Dev.** (N. B., Que., Ont.; N. Y., Appalachians, Ohio, Ind., Ky., W. Tenn., Okla.).

C. hemisphaerica (Sowerby) (**121**—22 25). Between 9 and 13 mm wide, transverse, flabellate; dorsal valve nearly flat in profile; surface marked by 8 to 12 rounded costae. **M. Sil.** (Clinton): Que.; N. Y., Appalachians.

***C. concava** (Hall) (**121**—19–21). Small, concavo-convex, outline subcircular. **L. Dev.** (Helderberg–Oriskany): Que.; N. Y., Appalachians, W. Tenn., Okla.

LEPTOCOELIA Hall 1859

(**Atrypa flabellites* Conrad). Small, planoconvex, coarsely costate; interior like *Coelospira*. **L.** to **M. Dev.** (Oriskany to Marcellus) (Que., Ont.; Me., N. Y., Appalachians, W. Tenn., Ill., Mo., Okla., Nev.; S. America).

***L. flabellites** (Conrad) (**121**—26–28). Range and distribution (except Nevada) same as genus.

ATRYPINA Hall and Clarke 1893

(**Leptocoelia imbricata* Hall). Small, pentagonal to subcircular in outline, costate, imbricate; ventral interior without dental plates; dorsal interior with small bilobed cardinal process; brachidium with spirals having few coils and with apices directed dorsomedially; jugum posterior, forming an acute angle inwardly directed. **M. Sil** to **L. Dev.** (Que.; N. Y., Appalachians, Ind., W. Tenn., Mo., Okla.).

A. disparilis (Hall) (**121**—29). Small, subcircular, about 6 mm wide; sulcate fold on ventral valve, composed of two costae; sulcus occupied by a single costa. **M. Sil.:** N. Y., Ind., W. Tenn.

***A. imbricata** (Hall) (**121**—30–32). Differs from preceding by its larger size (about 9 mm wide). **L. Dev.:** N. Y. (New Scotland), Appalachians, W. Tenn., Mo., Okla.

PUSTULINA Cooper 1942

(**Vitulina pustulosa* Hall). Small, planoconvex, costate, anterior commissure sulcate; exterior pustulose; ventral muscular area flabellate; median septum low. **M. Dev.** (Hamilton) (N. Y., Pa., Ind., Ky., Ill., Ark.; S. America).

***P. pustulosa** (Hall) (**121**—33–37). Range and distribution same as genus.

EOSPIRIFER Schuchert 1913

(**Spirifer radiatus* Sowerby). Shell plicate or nonplicate; entire surface covered with fine radiating lines; ventral valve with delthyrium covered with a

PLATE 122

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Cyrtospirifer disjunctus. Imp V and D ints; V ext. **4–10. Mucrospirifer** spp. **4–6. M. mucronatus.** V and D exts; Imp V int. **7, 8. M. argentarius.** V and D views. **9, 10. M. consobrinus.** V and D views. **11–14. Tylothyris missouriensis** (x2). Imp D int; two views of Imp V int; D ext. **15, 16. Mucrospirifer thedfordensis.** V and D views. **17–19. Brevispirifer lucasensis.** V, D, and S views. **20, 21. Tylothyris mesacostalis.** Imp D int; Imp V int. **22–26. Brevispirifer gregarius.** S and D views; V int; two D ints. **27–31. Costispirifer arenosus.** V and D views; D int; Imp V and D ints. **32–34. Fimbrispirifer venustus.** Detail of ornamentation (x2); D ext; Imp D int.

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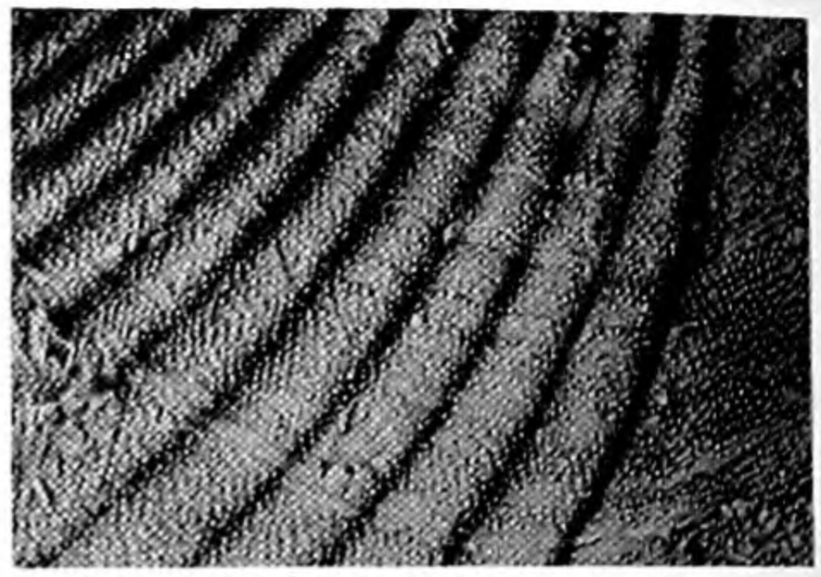
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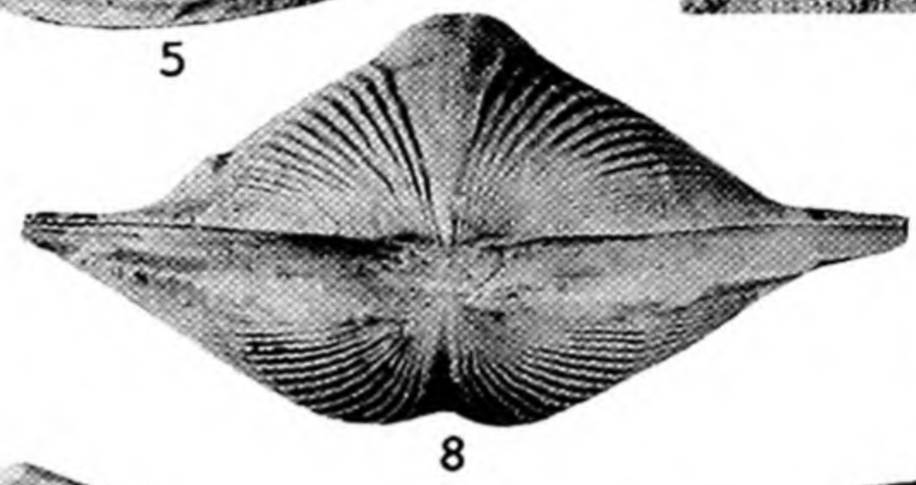
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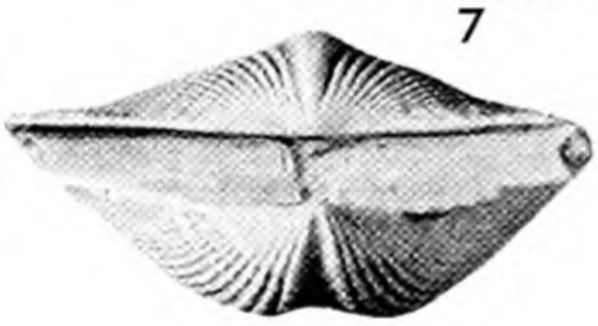
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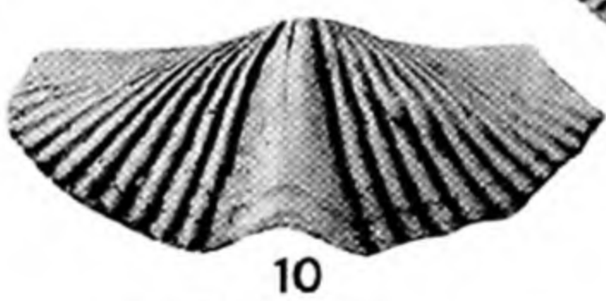
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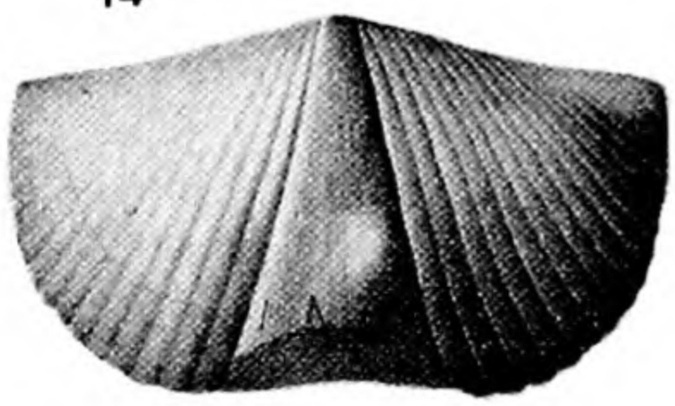
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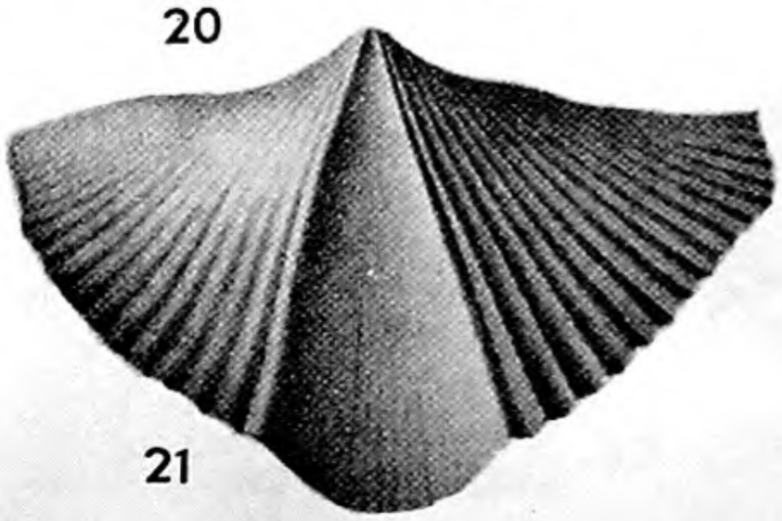
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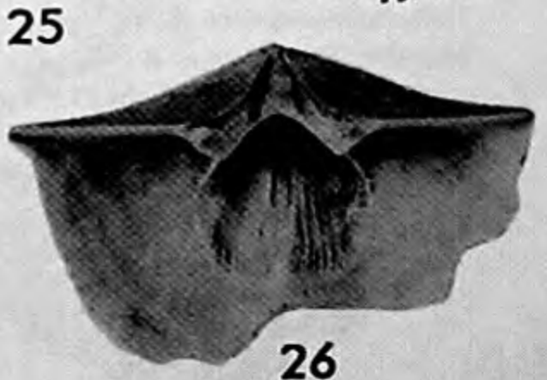
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pseudodeltidium; ventral interior with long dental plates; dorsal interior with long or short septa supporting dorsal plates. **M. Sil.** to **L. Dev.** (widespread throughout N. America).

***E. radiatus** (Sowerby) (**121**—47–49). Median sulcus and fold broad, fold flattened; flanks unplicated. **M. Sil.:** N. B., Ont.; N. Y., Ind., Ky., W. Tenn., Wis., Ill.

E. eudora (Hall). **M. Sil.:** Ohio, Ind., Ky., Tenn., Wis.

E. niagarensis (Conrad). **M. Sil.:** Ont.; N. Y.

E. macropleurus (Conrad) (**121**—56). Large, valves nearly equal in depth; sulcus deep; flanks marked by three rounded plications. **L. Dev.:** Me., N. Y. (New Scotland), Appalachians. W. Tenn.

CYRTIA Dalman 1829

(**Anomites exporrectus* Wahlenberg). Ventral valve pyramidal; dorsal valve gently convex with median fold; surface like *Eospirifer* but palintrope elongate and delthyrium covered with a convex, perforate pseudodeltidium; dental plates strong. **M. Sil.** (Que.; N. Y., Ind., Ky., W. Tenn., Ark.).

***C. exporrecta** (Wahlenberg) (**121**—38–40). **Niagaran:** Que.; Ind., Ky.

CYRTOSPIRIFER Nalivkin 1918

(**Spirifer verneuili* Murchison). Generally medium sized shells, often very wide, with costate fold and sulcus; dental plates strong; spire attached to socket plates; no supporting lamellae under socket plates. **U. Dev.** (Chemung–Conewango) (N. Y., Appalachians, Ia., Mont.; Mackenzie Valley; Canadian Rockies; Great Basin).

C. whitneyi (Hall) (**121**—53–55). Shells about 31 to 38 mm wide with prominent fold and sulcus; cardinal extremities alate. **U. Dev.** (Chemung): Ia., Nev., Ariz., N. Mex.

C. disjunctus (Sowerby) (**122**—1–3). Extremely wide with mucronate cardinal extremities. **U. Dev.** (Chemung): N. Y., Appalachians, Utah. (This is a loosely drawn species and the name probably should not be used for many post-Chemung types now placed here.)

C. monticola (Haynes) (**121**—52). Large, resembling and often mistaken for *C. whitneyi* but differing in its greater size, more elongate form, and narrower hinge. **U. Dev.** (post-Chemung): Alta.; Mont., Idaho, Nev.?, N. Mex.?

THEODOSSIA Nalivkin 1925

(**Spirifer anosoffi* Verneuil). Biconvex, completely costate spiriferids with rounded contours; fold low and poorly defined; sulcus shallow. **M.?** and **U. Dev.** of Europe; **U. Dev.** of U. S. A.

T. hungerfordi (Hall) (**121**—50, 51). **U. Dev.:** Ia., Ariz.

TENTICOSPIRIFER Tien 1938

(**Spirifer tenticulum* Verneuil). Small spiriferoids with fold and sulcus costate; ventral valve hemipyramidal and with long dental plates. **U. Dev.** (Ia., Mont., Wyo., Utah, Nev.).

T. utahensis (Meek) (**121**—45, 46). Measuring about 19 mm wide; interarea broad, beak sharply incurved; fold low and broad, sulcus moderately deep. **U. Dev.:** Mont., Wyo., Utah, Nev. (Jefferson).

T. cyrtiniformis (Hall and Whitfield) (**121**—41–44). Like the preceding but with narrower and more prominent dorsal fold. **U. Dev.:** Ia. (Hackberry).

MUCROSPIRIFER Grabau 1931

(**Delthyris mucronata* Conrad). Much wider than long, cardinal extremities often mucronate; fold and sulcus unmodified or with a single costa in the sulcus; surface costate, lamellose; ventral interior with short dental plates; dorsal interior with short plates supporting the crural bases. **M.** and **U. Dev.** (Marcellus–Ithaca) (Ont.; N. Y., Appalachians, Ia., Great Basin).

***M. mucronatus** (Conrad) (**122**—4–6). (Many species and varieties have been placed under the name *Spirifer pennatus* Atwater but this species is of too uncertain character to continue.) Very wide, attaining 100 mm in width but less than 25 mm in length; lateral extremities mucronate; fold low, sulcus narrow, usually bearing one more or less distinct costa. **M. Dev.** (L. Hamilton): N. Y., Pa., Md., Va.

M. argentarius (Meek) (**122**—7, 8). Small, measuring about 18 mm wide; fold and sulcus narrow; cardinal extremities alate. **U. Dev.:** Jefferson of Mont., Utah; Devils Gate of Nev.

M. thedfordensis Shimer and Grabau (**122**—15, 16). Resembling *M. mucronatus* but narrower and proportionally longer; cardinal extremities drawn into long points. **M. Dev.** (M. and U. Hamilton): Ont.; N. Y., Appalachians.

M. consobrinus (Orbigny) (**122**—9, 10). Alate, strongly lamellose; fold narrow, flattened, with a deep longitudinal furrow; sulcus with a strong costa; flanks marked by 8 to 12 costae. **Hamilton** (L. Moscow): N. Y.

TYLOTHYRIS North 1920

(**Cyrtia laminosa* McCoy). Externally like *Delthyris* but without spines on the lamellae; ventral interior

PLATE 123

[All figures are x1 and original by Cooper unless otherwise indicated.]

1, 2. Fimbrispirifer divaricatus. D and Post views. **3–5. Paraspirifer acuminatus.** D, Ant, and S views. **6–8. Spinocyrtia granulosa.** Detail of ornamentation (x4); D and Post views. **9–11. Acrospirifer gaspensis.** Detail of ornamentation (x4) [N Y St Mus, M 9]; Imp D and V ints. **12, 13. Brachyspirifer audaculus.** Post and D views. **14. Acrospirifer pinyonensis.** D ext. **15, 16. Acrospirifer murchisoni.** D ext; Imp V int. **17–19. Antispirifer harroldi.** Imp V int; Imp V exts on slab; V ext. **20–26. Platyrachella** spp. **20, 21. P. mesastrialis** [Pal N Y 4]. D and V exts. **22. P. lowensis.** D ext. **23–26. P. oweni.** D and S views; D int showing silicified spires; V int.

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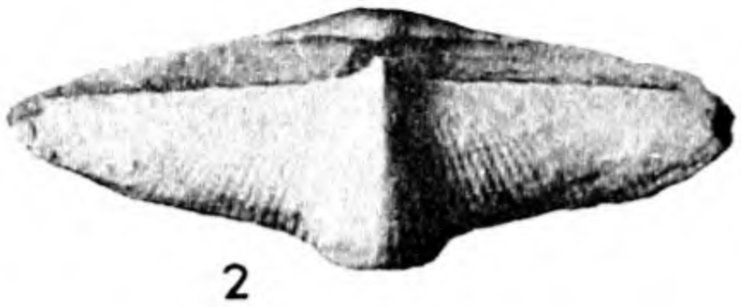
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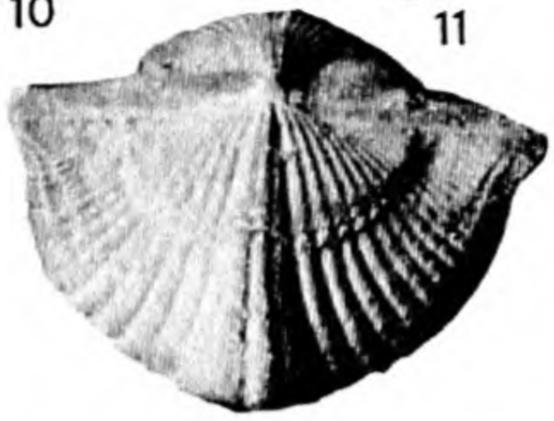
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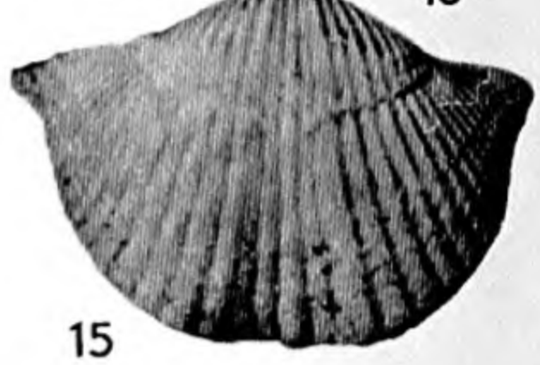
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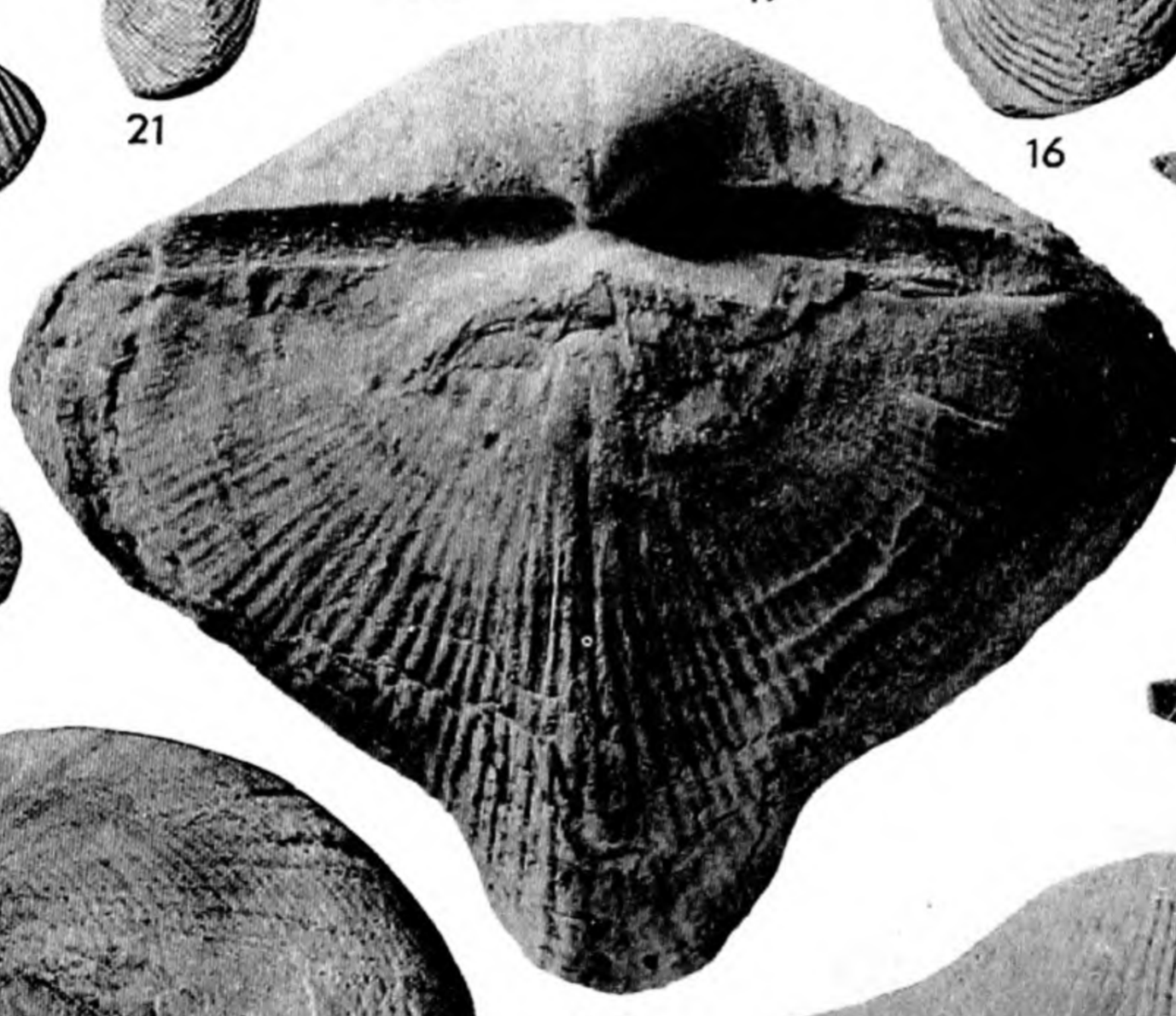

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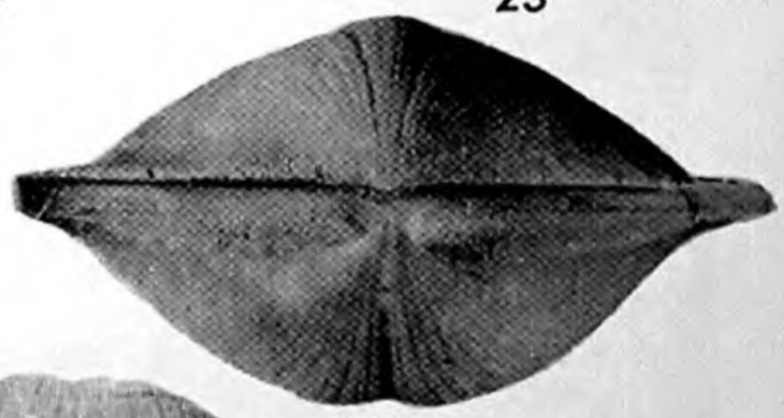
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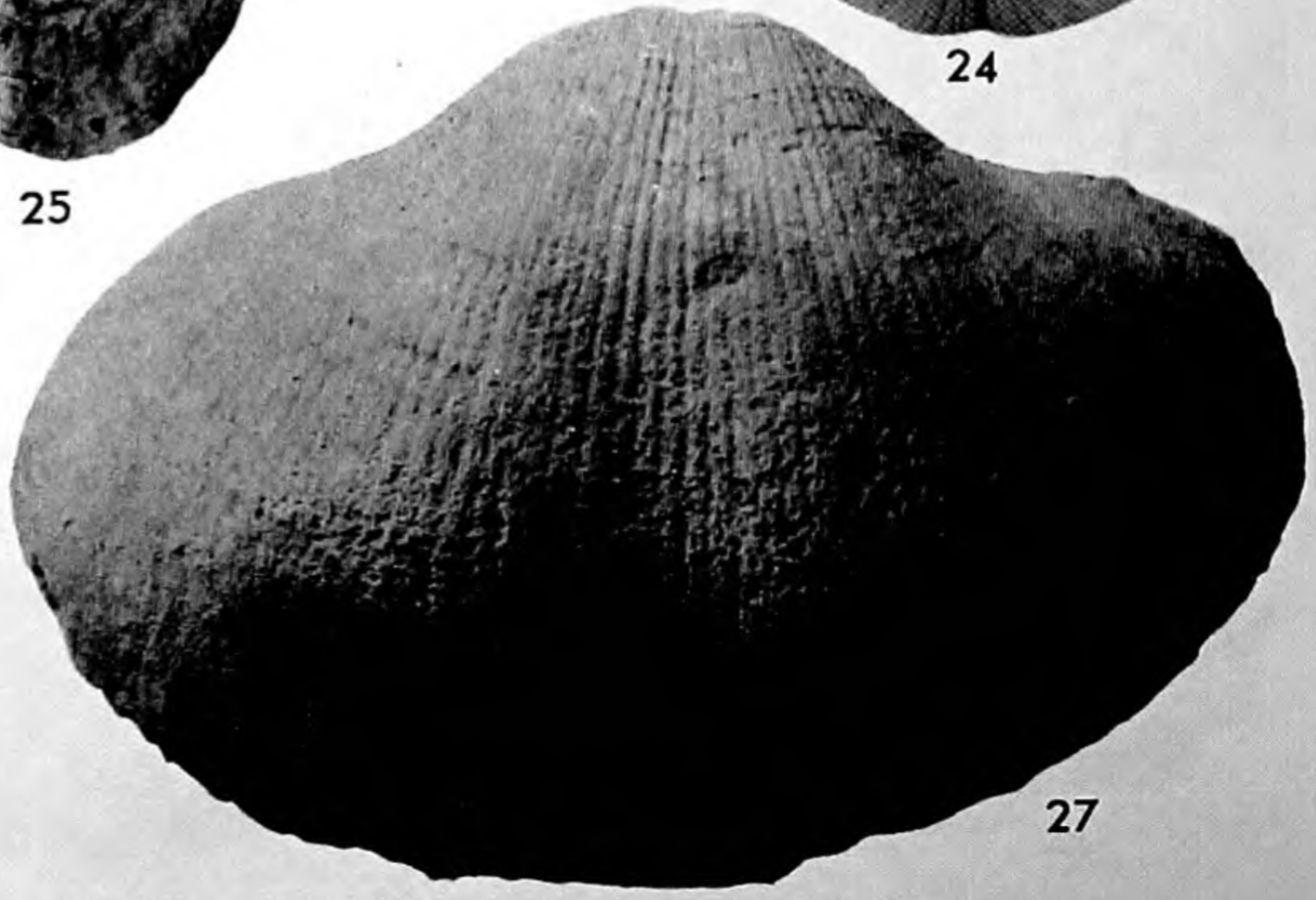
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with strong median septum and dental plates. **U. Dev.** to **Miss.** (Ont.; N. Y., Appalachians, Mich., Ind., Mississippi Valley).

T. mesacostalis Hall (**122**—20, 21). Large, usually with wide hinge and mucronate cardinal extremities; ventral sulcus with strong median costa; dorsal fold with corresponding narrow median groove. **U. Dev.** (Chemung–Canadaway): N. Y., Appalachians, Mont., Ariz.

T. missouriensis (Weller) (**122**—11–14). Small, about 16 mm wide with finely crowded lamellae, broad fold and flanks with three or four simple rounded costae. **Miss.** (Kinderhook): Ohio, Ind., Mississippi Valley.

BREVISPIRIFER Cooper 1942

(**Spirifer gregarius* Clapp). Exterior ornamentation and interior like *Mucrospirifer* but valves very narrow. **M. Dev.** (Onondaga and Marcellus) (Que.; N. Y., Mich., Ohio, Ind., Ill.).

***B. gregarius** (Clapp) (**122**—22–26). About 19 mm wide, beak strongly incurved; fold and sulcus without median costa. **Dev.** (U. Onondaga–Columbus): N. Y., Ohio, Ind.

B. lucasensis (Stauffer) (**122**—17–19). Like preceding but having a costa in the sulcus and stronger concentric lamellae. **M. Dev.:** Que.; Mich. (Dundee), Ohio (Delaware).

COSTISPIRIFER Cooper 1942

(**Spirifer planicostatus* Swartz). Large; fold and sulcus costate, costae broad and flat with narrow interspaces; costae covered with fine radial lines; dental plates strong; crural bases in dorsal valve cup-shaped and welded to sides of valve; notothyrial cavity broad and moderately deep. **L. Dev.** (Oriskany) (Que., Ont.; N. Y., Appalachians, Ill., W. Tenn., Mo., Great Basin).

***C. arenosus** (Conrad) (**122**—27–31). Same range and distribution as genus.

FIMBRISPIRIFER Cooper 1942

(**Spirifer venustus* Hall). Large, narrowly rounded sides, fold and sulcus costate; costae bifurcating; entire surface covered with zigzag concentric lamellae bearing a fringe of small spines along their edge; ventral interior with strong dental plates; dorsal interior with crural bases supported by short subparallel plates. **M. Dev.** (Onondaga–Tichenor) (Ont.; N. Y., Pa., Mich., Ohio, Ind., Ky., Ill., Mo.; Alaska).

F. divaricatus (Hall) (**123**—1, 2). Large, transverse, with narrowly rounded margins and subangular fold; costae strong, bifurcating or trifurcating to produce occasional fascicles. **Dev.** (L. Onondaga): Ont.; N. Y., Mich., Ohio, Ind., Mo.

***F. venustus** (Hall) (**122**—32–34). Like preceding in outline but with finer costae and lower fold. **M. Dev.** (Hamilton): Ont.; N. Y., Pa., Mich., Ohio, Ind., Ky.

PARASPIRIFER Wedekind 1926

(**Spirifer cultrijugatus* Roemer). Large, with low, broad costae bifurcating near front of valve; fold carinate and sulcus deep, noncostate; entire surface covered with concentric undulating lines of tiny spines. **Dev.** (Onondaga–Marcellus): Ont.; N. Y., Pa., Md., Ohio, Ind., Ky., Ill.

P. acuminatus (Conrad) (**123**—3–5). Large, anterolateral extremities narrowly rounded; hinge narrower than greatest shell width. **U. Onondaga:** Ont.; N. Y., Pa., Md., Ohio, Ind., Ky. (A related species occurs in the Marcellus of N. Y.)

P. bownockeri (Stewart). **Hamilton:** N. Y.?, Ohio.

SPINOCYRTIA Fredericks 1916

(**Delthyris granulosa* Conrad). Medium-sized to large; noncostate fold and sulcus; costae broad and low, entire surface covered with minute tear-shaped granules. **M. Dev.** (Hamilton) (Ont.; N. Y., Pa., Mich., Ind., Ia.).

***S. granulosa** (Conrad) (**123**—6–8). **Hamilton, Tully:** Ont.; N. Y., Pa.

BRACHYSPIRIFER Wedekind 1926

(**Spirifer carinatus* Schnur). Generally wide, with long ventral palintrope; costate, costae smooth; fold and sulcus smooth; ventral interior with strong dental plates; dorsal interior with short median septum. **M. Dev.** (Ont.; N. Y., Pa., Md., Va., Mich., Ohio, Ind., Ky., Mo., Ark.)

B. audaculus (Conrad) (**123**—12, 13). Attaining a width of 50 mm; cardinal extremities acute; fold narrow, moderately high, rounded; flanks with 20 to 30 narrowly rounded, crowded costae; growth lamellae distant. **Dev.** (Hamilton): N. Y., Appalachians, Ohio, Ind., Ky., Ill., Mo., Ark.

ACROSPIRIFER Wedekind 1926

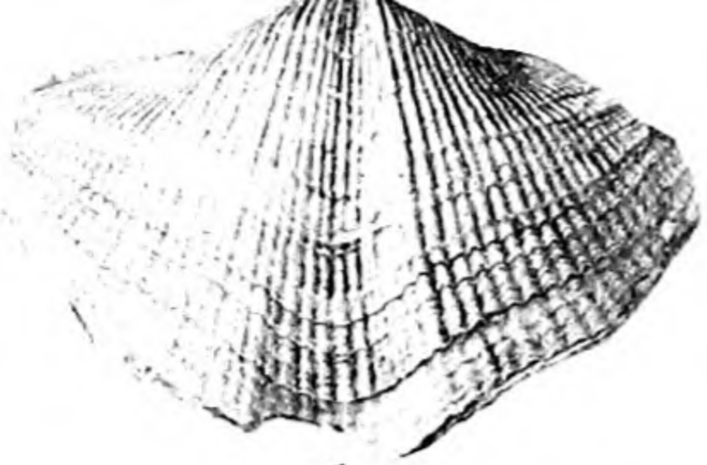
(**Spirifer primaevus* Steiniger). Subsemicircular to transversely semielliptical, costate and lamellose spiriferoids; fold and sulcus noncostate; dental plates strong, muscular field large, elongate-oval; dorsal interior with thick socket plates. **U. Dev.** (widespread).

A. gaspensis (Billings) (**123**—9–11). Transverse, large, attaining a width of 44 mm; sulcus moderately wide; flanks with 10 to 13 costae. **Dev.** (Gaspé): N. B., Que.; Me.

PLATE 124

[All figures are x1 and after Weller [Ill G S, M 1] unless otherwise indicated.]

1–27. Spirifer spp. 1–5. S. lateralis. V, D, Post, Ant, and S views. **6–9. S. increbescens.** Ant, V, D, and S views. **10–13. S. bifurcatus.** V, D, Ant, and S views. **14–17. S. keokuk.** D, V, S, and Ant views. **18, 19. S. orestes** [original]. S. and D views. **20–22. S. rockymontanus** [original]. V, S, and D views. **23, 24. S. arkansanus** [original]. D and Post views. **25–27. S. grimesi.** D, S, and V views.



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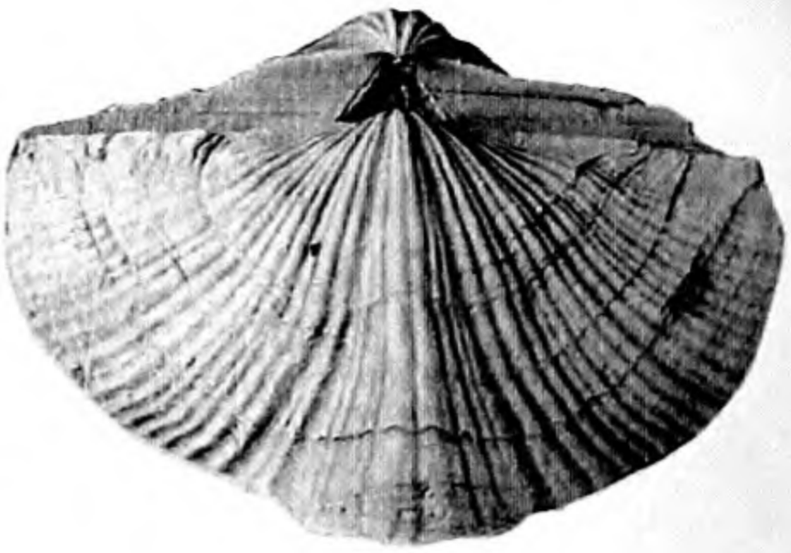

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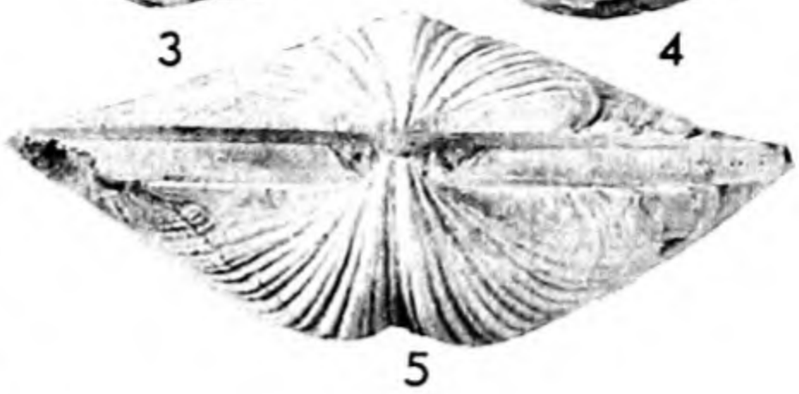

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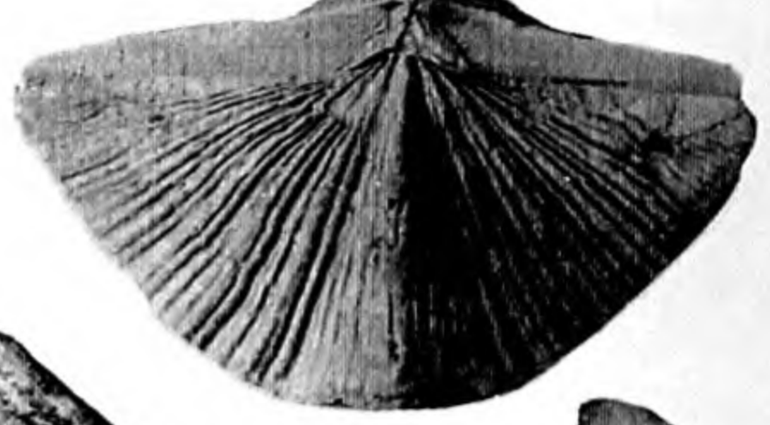

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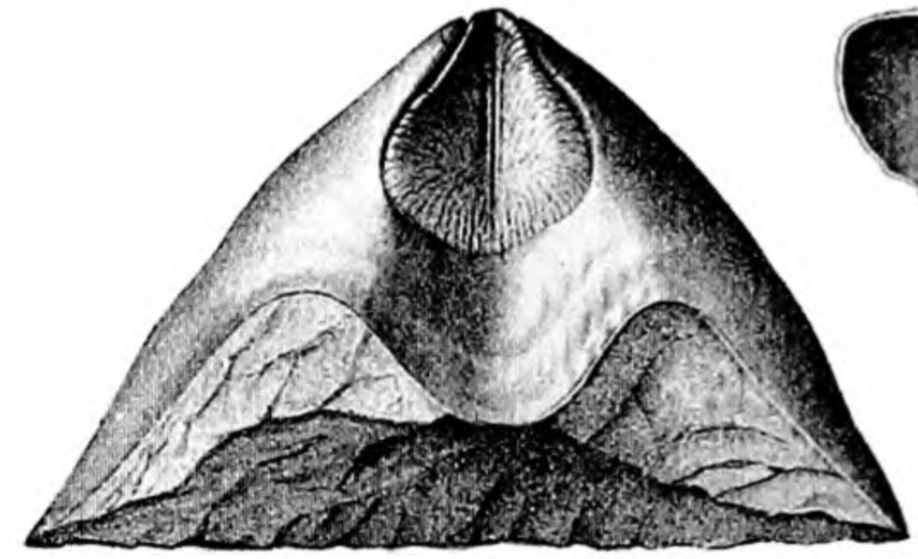

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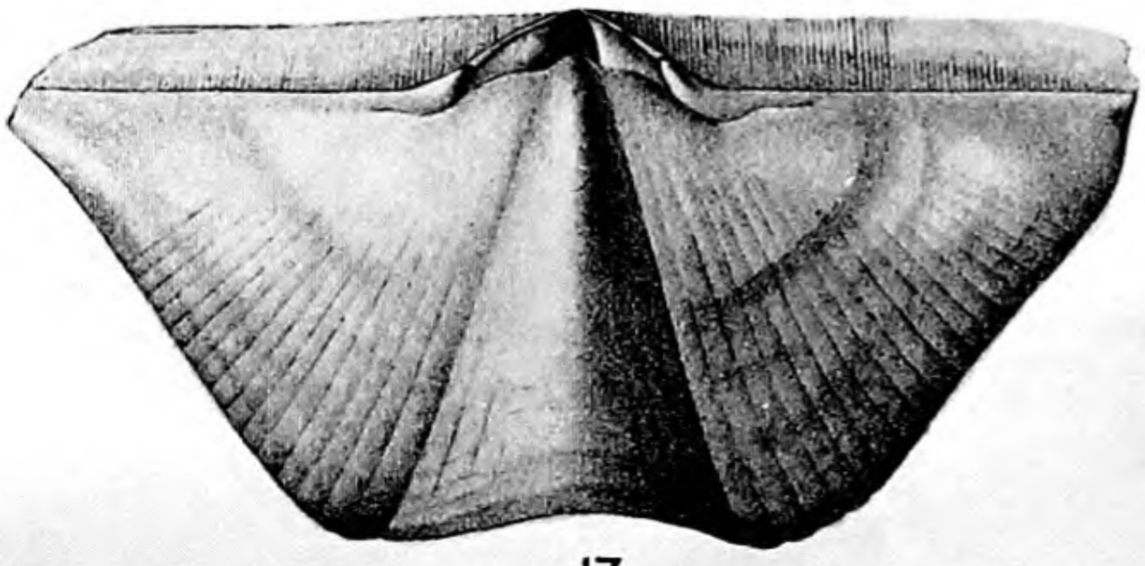

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A. murchisoni (Castelnau) (**123**—15, 16). Large, transverse, over 50 mm wide when full grown; fold narrowly rounded; flanks with six or seven distant, strong and narrowly rounded costae. **L. Dev.** (Oriskany): N. B., Que., Ont.; N. Y., Appalachians, W. Tenn., Ill., Mo.

A. pinyonensis (Meek) (**123**—14). About 32 mm wide; sulcus shallow; fold low and flattened; flanks with 11 costae, the outer three indistinct. **Dev.** (L. Nevada): Nev.

ANTISPIRIFER Williams 1916

(**A. harroldi* Williams [**123**—17–19]). Small spiriferoid with flat ventral valve and convex dorsal valve; hinge wide, dental plates well developed; ventral musculature and dorsal interior as in *Acrospirifer*; surface costate, lamellose. **L. Dev.** (Me.)

PLATYRACHELLA

C. L. Fenton and M. A. Fenton 1924

(**Spirifera macbridei* Calvin). Large, flanks costate, fold and sulcus noncostate or with occasional secondary anterior costation; entire surface covered with fine radial lines of granules or fine radial lines when granules are worn off; palintrope long, ranging from nearly flat to strongly curved; ventral interior with thick dental plates and short flat apical plate; dorsal interior with transverse cardinal process and shallow brachial supports. **M.** and **U. Dev.** (Marcellus to Chemung) (N. Y., Appalachians, Ia.).

P. oweni (Hall) (**123**—23–26). About 37 mm wide; incurved ventral beak, low somewhat flattened fold marked by a narrow furrow; flanks marked by about 14 broadly rounded costae. **M. Dev.:** Ind., Ky.

P. iowensis (Owen) (**123**—22). Large, mucronate, with subcarinate fold and broad curved interarea. **M. Dev.:** Ia. (Cedar Valley).

P. mesastrialis (Hall) (**123**—20, 21). Suggests *P. iowensis* but differs in being smaller, less mucronate, and in having a broad, low fold, and broad, low costae on flanks. **Dev.** (Hamilton–Chemung): N. Y., Appalachians.

SPIRIFER Sowerby 1814

(**Anomites striatus* Martin). Medium-sized to large, transverse, generally with hinge forming widest part; completely costate; dental plates stout; brachidium with many coils laterally directed; jugum incomplete; cardinal process a roughened area under beak. **Miss.** to **L. Penn.** (all areas of outcrop).

S. grimesi Hall (**124**—25–27). Very large, broad, with poorly defined fold and sulcus; costae numerous. **Miss.** (Burlington): Ill., Ala., Ia., Mo., Ark., Okla., Nev.

S. lateralis Hall (**124**—1–5). Very wide and short, with high, carinate fold. **Miss.** (Warsaw): Ind., Ky., Tenn., Ala.

S. arkansanus Girty (**124**—23, 24). Moderately large, hinge width 55 mm, length about 40 mm; sulcus moderately deep; tongue long, acute; fold low, subacuminate anteriorly, poorly defined posteriorly. **Miss.:** Ark. (Spring Creek), Okla. (Mayes).

S. orestes Hall and Whitfield (**124**—18, 19). Small, with rounded lateral margins; mid-width about 25 mm, length 22 mm; hinge narrower than mid-width; sulcus shallow, fold low. **U. Dev.** (Hackberry and equivalents): Ia., Ariz., N. Mex.

S. keokuk Hall (**124**—14–17). About 33 mm wide; sides narrowly rounded; rotund ventral umbo; sulcus broad; flanks with 11 to 15 costae. **Miss.** (Keokuk): S. Appalachians, Ill., Ia.

S. bifurcatus Hall (**124**—10–13). Small, about 19 mm wide; ventral valve gibbous; fold consisting of two costae, sulcus with one; flanks with five to eight simple costae. **Miss.** (Warsaw): S. Appalachians, Ind., Ky., Tenn.

S. increbescens Hall (**124**—6–9). Length slightly less than width, about 38 mm wide along hinge; cardinal extremities alate; fold low; costae strong, broadly rounded, numbering 14 to 18 on flanks, and 4 on fold. **Miss.** (Chester): S. Appalachians, Ky., Mississippi Valley.

S. rockymontanus Marcou (**124**—20–22). Suggesting *S. increbescens*, but smaller, with less incurved beak, and more elevated fold. **L. Penn.:** S. Appalachians, Ohio, Okla., Colo., Tex., N. Mex.

NEOSPIRIFER Fredericks 1919

(**Spirifer fasciger* Keyserling). Generally large and transverse, rarely narrow, spiriferoids with strong fasciculate costae. **Penn., Perm.** (all areas of these rocks).

N. dunbari King (**125**—7, 8). Medium-sized, subtriangular, widest at hinge; sulcus narrow; tongue moderately long; fold narrowly rounded; costae bold, subangular, strongly fasciculated. **Penn.** (Marmaton–Wabaunsee): Midcontinent.

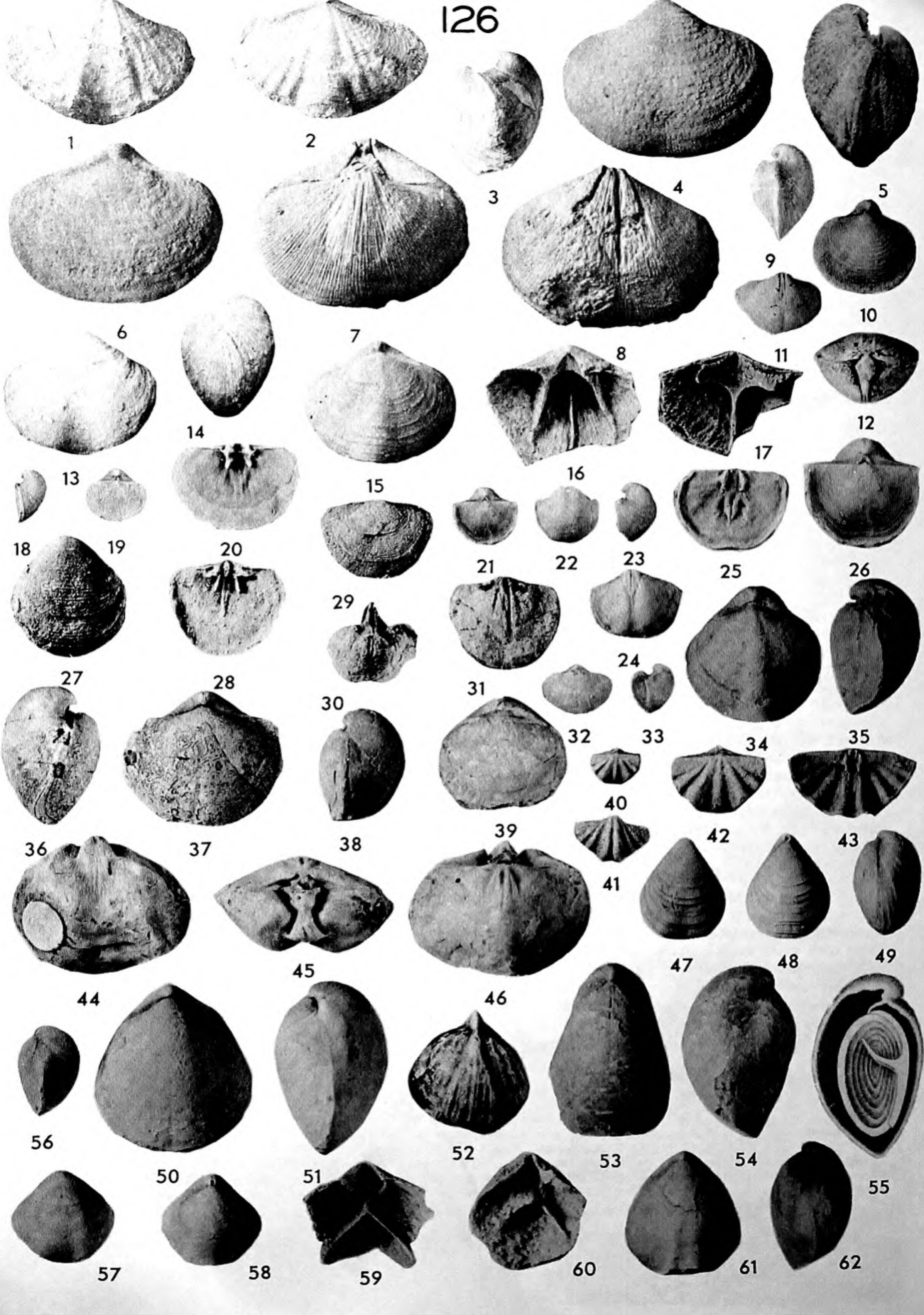
N. cameratus (Morton) (**125**—5, 6). Large, resembling *N. dunbari* but differs in having low rounded costae and very little fasciculation at the beak; fold low and rounded, sulcus shallow, rounded; young specimens transverse, adult with bluntly angular cardinal extremities and length exceeding two-thirds the width. **L. Penn.:** Pa., Ohio, Ia., Mo., Okla., Tex.

N.? texanus (Meek) (**125**—3, 4). Small, longer than wide, with length about 25 mm and width 18 mm. **Penn.:** Okla., Tex.

PLATE 125

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–8. Neospirifer spp. 1, 2. N. condor. V and D views. **3, 4. N.? texanus.** D and S views. **5, 6. N. cameratus.** Post and D views. **7, 8. N. dunbari.** Post and D views. **9–11. Brachythyris subcardiformis** [Ill G S, M 1]. V, D, and S views. **12–17. Syringospira spp. 12–14. S. prima** [USGS, B 391]. S, Post, and Ant views. **15–17. S. alta** [Pal N Y 4]. Post and Ant views of Imp V int; Imp D int. **18–20. Crispella crispa** [Pal N Y 8]. V int (x3); D ext (x2); D int (x3). **21, 22. Delthyris perlamellosa.** V int; D ext. **23, 24. Delthyris sulcata** [Pal NY 8 (2)]. D ext; enlarged surface of ext. **25. Crispella vanuxemi.** Slab showing numerous specimens.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N. condor (Orbigny) (**125**—1, 2). Large, transverse, usually alate, width approaching twice the length. **Perm.** (Wolfcamp): Tex., N. Mex., Cal.

BRACHYTHYRIS McCoy 1844

(**Spirifera ovalis* Phillips). Length and width subequal, outline oval to subcircular, hinge short; fold and sulcus costate; costae broad and rounded; dental plates obscure. **Miss.** (Ind., Mississippi Valley, Okla.).

B. subcardiformis (Hall) (**125**—9–11). Large, suborbicular in outline, 8 to 10 simple costae increasing in width anteriorly; fold with 4 costae, sulcus with 3. **Miss.** (Warsaw): Ind., Ill.

SYRINGOSPIRA Kindle 1909

(**S. prima*). Ventral palintrope exceptionally long and flat; delthyrium closed by a long flat pseudodeltidium; dorsal valve as in *Syringothyris*; fold and sulcus costate. **U. Dev.** (Conewango) (N. Y., Pa., Ohio, N. Mex.).

***S. prima** Kindle (**125**—12–14). **U. Dev.:** N. Mex. (Percha).

S. alta Hall (**125**—15–17). Approaching 75 mm in width; cardinal extremities alate; fold low and broad; interarea wider than long. **U. Dev.** (Conewango): N. Y., Pa., Ohio.

CRISPELLA Kozlowski 1929

(**Spirifer crispus* Hisinger). Shells small, short-hinged, coarsely costate; lamellose, the lamellae bearing simple spines; ventral interior with long dental plates but no median septum. **M.** and **U. Sil.** (N. Y., Appalachians, Ohio, Ind., Ky., W. Tenn., Mo., Okla.).

***C. crispa** (Hisinger) (**125**—18–20). Small, subelliptical in outline; surface marked by six to eight broad costae. **M. Sil.:** N. S., Ont.; N. Y., Ind.

C. vanuxemi Hall (**125**—25). Small, with narrowly rounded sides; surface marked by two to four broad costae on the flanks; fold and sulcus not strongly developed. **Sil.** (Manlius): N. Y., N. J., Appalachains.

DELTHYRIS Dalman 1828

(**D. elevata*). Larger than *Crispella*, usually wide-hinged, costate, lamellose, lamellae bearing short simple spines; ventral interior with long dental plates and a high median septum. **M. Sil.** to **L. Dev.** (N. B., Que.; N. Y., Appalachians, W. Tenn., Ill., Mo., Okla.).

D. sulcata Hisinger (**125** 23, 24). Widest at hinge; sulcus low, narrowly rounded; four to seven costae on flanks. **M. Sil.:** Ont.; N. Y.

D. perlamellosa (Hall) (**125**—21, 22). Large, about 38 mm wide; ventral valve with strongly incurved beaks; delthyrium covered by a deltidium; fold narrowly rounded; sulcus deep; flanks marked by four to six costae. **L. Dev.:** Que.; N. Y. (New Scotland), Appalachians, W. Tenn., Mo., Okla.

ELYTHA Fredericks 1918

(**Delthyris fimbriatus* Conrad). Transversely elliptical in outline; biconvex, valves subequal in depth; costate, with low rounded costae crossed by distant lamellae bearing one row of long double-barreled spines; ventral valve with strong dental plates and median septum; dorsal valve with strong socket plates supported by short septa; no median septum. **Dev.** (Hamilton) (N. Y., Appalachians, Mich., Ohio, Ind., Ky., Ia., Great Basin; Mackenzie Valley).

E. fimbriata (Conrad) (**126**—1–3). **Hamilton** and **Tully:** Ont.; N. Y., Appalachians, Mich., Ind., Ky., Tenn., Ill.

TORYNIFER Hall and Clarke 1895

(**T. criticus* H and C = *Spirifer pseudolineatus* Hall). Outline subelliptical, profile biconvex, valves subequal in depth; uniplicate; surface marked by concentric lamellae bearing a row of fine double-barreled spines; dental plates strong; median septum of ventral valve usually fairly well developed; dorsal interior with long concave hinge plate supported by a low median septum. **Miss.** (S. Appalachians, Ind., Ky., Mississippi Valley, Ark., Okla.).

***T. pseudolineata** (Hall) (**126**—4–8, 16, 17). Large, attaining a width of more than 38 mm; sulcus moderately deep but fold low; interior with numerous radiating ridges. **Miss.** (Keokuk): Ky., Ind., Mississippi Valley.

T. setigera Hall (**126**—13–15). Like the preceding but form differing in proportionally narrower, lower fold and less development of internal radii. **Miss.** (Chester): Ky., Ala., Mississippi Valley, Ark.

PHRICODOTHYRIS George 1932

(**P. lucerna*). Shells of medium size, noncostate, with concentric rows of double-barreled, hollow

PLATE **126**

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Elytha fimbriata. V, D, and S views. **4–8. Torynifer pseudolineata** [Ill G S, M 1]. V, S, and D views; Imp D and V ints. **9, 10. Phricodothyris perplexa.** S and D views. **11, 12. Prosserella modestoides.** Imp V int; Post view of int F (x2). **13–17. Torynifer** spp. **13–15. T. setigera** [Ill G S, M 1]. V, S, and D views. **16, 17. T. pseudolineata.** V and D ints (x2). **18–20. Crurithyris planoconvexa.** S and D views; D int (x3). **21–26. Ambocoelia umbonata.** D, V, and S views; Imp V int (x2); D int (x3); D ext (x2). **27–31. Echinocoelia ambocoelioides** (x2) [GSA, B 46]. V ext; D int and ext; Imp V int; Imp D int. **32, 33. Emanuella subumbona.** D and S views. **34, 35. "Martiniopsis"? maia.** D and S views. **36, 37. "Martiniopsis"? kirki.** S and D views. **38, 39. Emanuella pennsylvanica.** S and D views. **40–43. Metaplasia pyxidata.** D and V exts; D ext (x2); D int (x2). **44–46. Martiniopsis laevis.** V, Post, and D views of an Int F. **47–49. Whitfieldella nitida.** V, D, and S views. **50–55. Cryptothyrella** spp. **50, 51. C. quadrangularis.** D and S views. **52–55. C. cylindrica.** Imp V muscle area; D and S views; S view of spiralium showing jugum [Pal N Y 8]. **56–62. Merista** spp. **56–59. M. tennesseensis.** S, V, and D views; V int (x2). **60–62. M. typa** V int (x2); D and S views.

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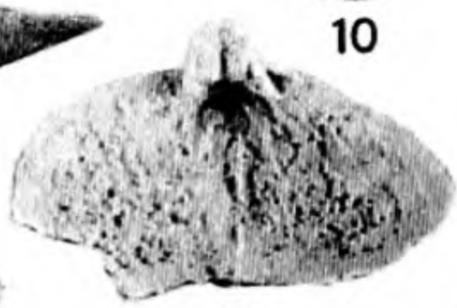
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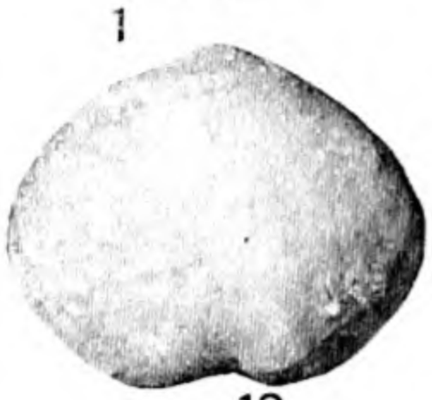
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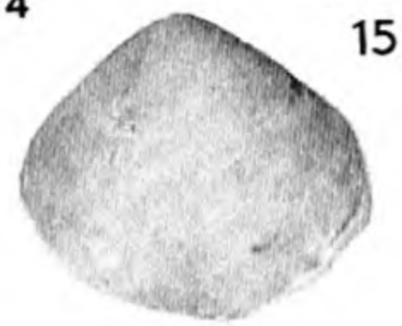
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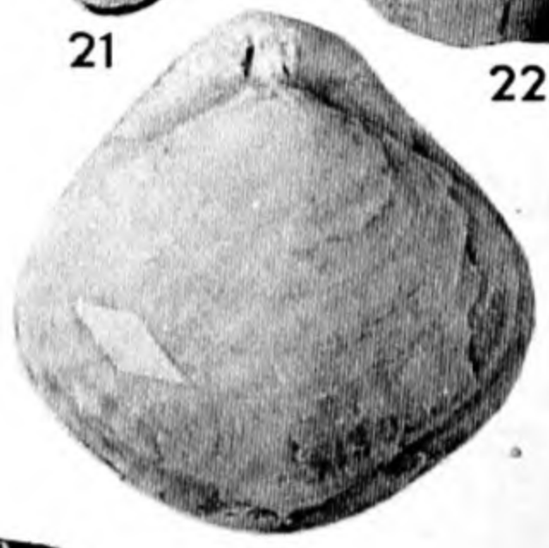
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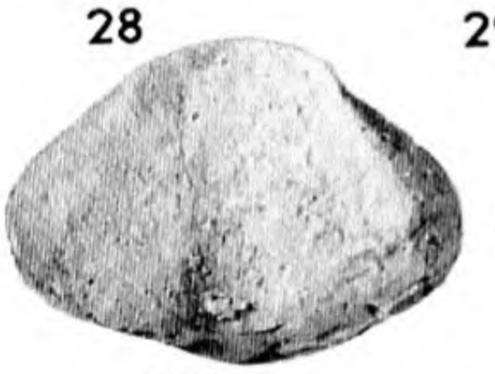
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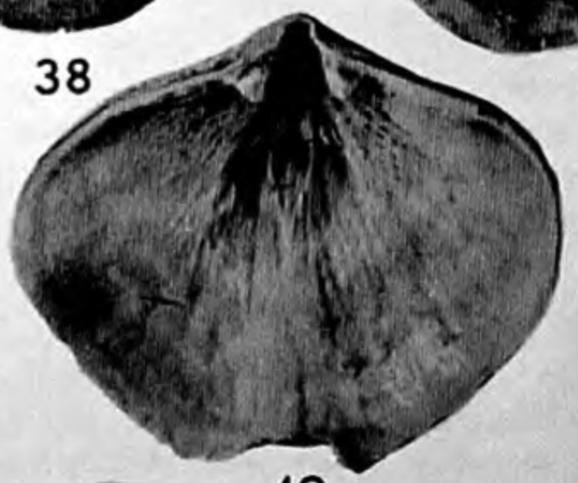
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spines; ventral valve with narrow interarea; ventral interior without dental plates or median septum; dorsal interior without median septum. **Penn., Perm.** (all areas of outcrop).

P. perplexa (McChesney) (**126**—9, 10). Broadly elliptical in outline, attaining a width of 25 mm; ventral valve deeper than dorsal; beak strongly incurved; lamellae narrow, numerous. **Penn.:** Ind., Ky., Mo., Neb., Kan., Okla., Tex., N. Mex., western U. S. A.

PROSSERELLA Grabau 1910

(**P. modestoides*). Exterior nonspinose but otherwise suggesting *Elytha*; ventral interior with long, closely spaced dental plates defining a narrow delthyrial cavity; dorsal plates as in *Elytha*. **Dev.** (Detroit River (= Onondaga) of Ont.; Mich., Ohio; Ind. (Pendleton).

***P. modestoides** Grabau (**126**—11, 12). Range and distribution same as genus.

AMBOCOELIA Hall 1860

(**Orthis umbonata* Conrad). Small, subpentagonal in outline, smooth or with scattered spines; beak incurved; hinge narrow; ventral valve strongly convex with narrow sulcus; dorsal valve gently convex in profile; ventral interior with no dental plates; dorsal interior with adductor impressions located at or anterior to middle. **Dev., Miss.** (N. Y., Appalachians, Mich., Ohio, Ind., Ky., Rocky Mts.).

***A. umbonata** (Conrad) (**126**—21–26). **Hamilton:** Ont.; N. Y., Appalachians, Ohio, Ind., Ky.

CRURITHYRIS George 1931

(**Spirifer urei* Fleming). Like *Ambocoelia*, small, hinge narrower than greatest width; ventral umbo incurved; surface smooth to spinose; cardinal process sessile, elevated, triangular, tuberculate; dorsal musculature located just anterior to cardinalia; scars elongate. **Dev.–Perm.** (Ohio, Ind., Midcontinent, Tex.).

C. planoconvexa (Shumard) (**126**—18–20). Small, attaining a width of 10 mm; dorsal valve nearly flat but prominent convex umbo; outline nearly circular. **Penn.:** Ind., Ky., Ill., Midcontinent, Tex.

ECHINOCOELIA Cooper and Williams 1935

(**E. ambocoelioides*). Like *Crurithyris* internally but exterior provided with concentric rows of fine spines. **M. Dev.** (Skaneateles–Tully) (N. Y. and Pa.).

***E. ambocoelioides** C and W (**126**—27–31). **Tully:** N. Y., Pa.

MARTINIOPSIS Waagen 1883

(**M. inflata*). Shells of about medium size with smooth exterior; a shallow ventral sulcus and low dorsal fold; beak strongly incurved; delthyrium covered with a deltidium; ventral interior with long dental plates. **M. Dev.** (Ont.; Ohio, Nev.).

"M." maia (Billings) (**126**—34, 35). Large, subcircular, length and width about 32 mm; fold low and narrow; sulcus best defined in front half; valves subequal in depth. **M. Dev.:** Ont.; Ohio (Delaware).

"M." kirki Merriam (**126**—36, 37). Smaller than preceding, attaining a length and width of about 25 mm; sulcus narrow and deeper; fold low, bearing a shallow longitudinal depression. **M. Dev.:** Nev. (Nevada).

"M." laevis (Hall) (**126**—44–46). Large, elliptical in outline, attaining 65 mm in width; length about two-thirds the width; sulcus wide; ventral muscular area small, dental plates short. **U. Dev.** (Ithaca): N. Y., Appalachians.

EMANUELLA Grabau 1925

(**E. takwanensis* Kayser). Shells generally small, wider than long, with smooth exterior, obscure fold and sulcus, and without dental plates; dorsal socket plates convergent. **M.** and **U. Dev.** (Ont.; N.Y., Pa., Mich.).

E. subumbona (Hall) (**126**—32, 33). Small, transversely elliptical, attaining almost 12 mm in width; anterior commissure rectimarginate. **M. Dev.** (Hamilton–Tully): N. Y., Pa.

E. pennsylvanica (Willard) (**126**—38, 39). Large, subpentagonal in outline but with length and width about equal; ventral valve much deeper than dorsal; ventral beak strongly incurved. **M. Dev.:** Pa. (Tully).

METAPLASIA Hall and Clarke 1893

(**Spirifer pyxidatus* Hall). Small; smooth or with fine concentric lines; spiriferoid in appearance with a wide hinge; strong ventral fold and dorsal sulcus; ventral interior without dental plates; dorsal cardinal process bilobed. **L. Dev.** (Oriskany–L. Onondaga) (Que., Ont.; N. Y., Appalachians, W. Tenn., Ill., Mo.).

***M. pyxidata** (Hall) (**126**—40–43). **L. Dev.:** Ont.; N. Y. (Oriskany), Appalachians, W. Tenn., Ill., Mo.

ROSTROSPIRACEA. Impunctate, rostrate, having spiralium with more or less complicated jugum.

PLATE 127

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–4. Hyattidina congesta [Pal N Y 8 (2)]. D ext; D int showing spiralia; Imp D int; hinge plate. **5–11. Nucleospira** spp. **5–7. N. concinna.** V, D, and S views. **8, 9. N. ventricosa.** Two views of D int. **10, 11. N. pisiformis.** D and S views. **12–15. Meristina maria.** V, D, and S views; V int. **16–27. Meristella** spp. **16. M. barrisi.** D ext. **17–19. M. atoka.** V, D, and S views. **20–22. M. arcuata.** V, S, and D views. **23–25. M. robertsensis.** D ext; V and D ints. **26, 27. M. nasuta.** D and S views. **28–31. Camarospira eucharis** [Pal N Y 8 (2)]. V and D views; Imp V int; S view. **32–36. Pentagonia bisulcata.** V, Post, and D views; V and D ints. **37. Pentagonia unisulcata** (x2). D ext. **38–51. Athyris** spp. **38. A. cora.** D ext. **39–43. A. spiriferoides.** V, D, and S views; V and D ints. **44, 45. A. lamellosa** [Ill G S, M 1]. V ext; Imp V int. **46, 47. A. angelicoides** [GSA, SP 25]. V and Ant views. **48–51. A. angelica** [Pal N Y 4]. D and V views of Int F; V and S views.

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WHITFIELDELLA Hall and Clarke 1893

(**Atrypa nitida* Hall). Smooth, subequally convex, rostrate shells; ovate in outline; foramen circular; dorsal hinge plate concave, supported by a median septum; socket plates thick, elevated; brachidium with two laterally directed spiral cones joined by a Y-shaped jugum, the tail of the Y curved posteroventrally. **L. Sil. to L. Dev.** (Ont.; N. Y., Appalachians, Mich., Ohio, Ind., Ky., W. Tenn., Wis., Ill., Mo.).

***W. nitida** (Hall) (**126**—47–49). **M. Sil.:** N. Y., Ind., W. Tenn.

CRYPTOTHYRELLA Cooper 1942

(**Whitfieldella quadrangularis* Foerste). Large, elongate-oval, lenticular in profile; ventral beak small, incurved; foramen minute; anterior commissure rectimarginate to uniplicate; surface smooth; ventral muscle field large, triangular; dorsal interior as in *Whitfieldella*. **L. Sil.** (N. Y., Appalachians, Ohio Valley).

C. cylindrica (Hall) (**126**—52–55). Large, attaining a length of 38 mm and a width of 25 mm; fold low, sulcus originating near middle of ventral valve. **L. Sil.:** Anticosti; Ont.; N. Y., Ohio (Brassfield).

***C. quadrangularis** (Foerste) (**126**—50, 51). **L. Sil.** (Brassfield): Ohio, Ky.

MERISTA Suess 1851

(**Terebratula herculea* Barrande). Exterior like *Meristella* or *Whitfieldella*; ventral interior with inverted V-shaped chamber with apex of V directed posteriorly between dental plates; hinge plate concave, supported by median septum; jugum having form of a scissors handle. **M. Sil.** to **L. Dev.** (Que.; N. Y., Appalachians, W. Tenn., Okla.).

M. typa (Hall) (**126**—60–62). Large, subpentagonal in outline, attaining 25 mm in length; fold low, sulcus shallow, both defined best near front margin; ventral chamber rounded above. **U. Sil.** (Keyser): Pa., Md.

M. tennesseensis Hall and Clarke (**126**—56–59). Smaller than preceding but with similar outline and profile; about 15 mm long; anterior emarginate; sides more narrowly rounded than in *M. typa*; ventral chamber angular above. **M. Sil.:** W. Tenn. (Brownsport).

HYATTIDINA Schuchert 1913

(**Athyris congesta* Conrad). Exterior subpentagonal, ventral valve with strong median sulcus and two lateral sulci; dorsal valve with corresponding folds; ventral valve with strong dental plates; hinge plate divided by a narrow groove; median septum absent; spire loosely coiled; jugum as in *Whitfieldella*. **M. Sil.** (Anticosti; Ont.; N. Y., Appalachians).

***H. congesta** (Conrad) (**127**—1–4). **Clinton:** Ont.; N. Y.

NUCLEOSPIRA Hall 1857

(**Spirifer ventricosa*). Small, subcircular, beak small; surface covered with short spines; ventral interior without dental plates; muscular field flabellate; median septum extending from delthyrial cavity nearly to front margin; dorsal hinge plate recurved into ventral delthyrial cavity; jugum with long process extending almost to ventral valve. **M. Sil.–L. Miss.** (Que., Ont.; N. Y., Appalachians, Ind., Ky., W. Tenn., Okla.).

N. pisiformis (Hall) (**127**—10, 11). Nearly circular in outline; with a diameter of nearly 13 mm; thickness moderate; spines very slender. **M. Sil.** (Waldron): Ind., W. Tenn.

***N. ventricosa** (Hall) (**127**—8, 9). Outline slightly elliptical; valves deep. **L. Dev.** (New Scotland and equivalents): N. Y., Appalachians, W. Tenn., Okla.

N. concinna (Hall) (**127**—5–7). Larger than either of preceding; broadly elliptical in outline; valves deep. **M. Dev.** (Hamilton): Ont.; N. Y., Pa., Mich., Ind., Ky.

MERISTINA Hall 1867

(**Meristella maria*). Large, valves of subequal depth; low dorsal fold, smooth surface; ventral interior like *Meristella*; hinge plate divided, supported by a long median septum; jugum consisting of two lateral branches inclined backward and forming a stem bifurcated at its end. **M. Sil.** (Que.; N. Y., Ind., W. Tenn., Wis., Ill., Mo., Okla.).

***M. maria** (Hall) (**127**—12–15). **M. Sil.:** N. Y., Ind., W. Tenn.

MERISTELLA Hall 1860 (**106**-18)

(**Atrypa laevis* Vanuxem). Small to large, smooth, biconvex usually with a dorsal fold; oval in outline; rostrate, with circular foramen; ventral interior with dental plates and deeply impressed muscular area forming a trapezoidal or triangular pit; hinge plate divided, supported by a strong median septum and forming a small subrostral chamber; jugum similar to *Merista*. **U. Sil.** to **M. Dev.** (Keyser–Tully) (N. B., Que., Ont.; Me., N. Y., Appalachians, W. Tenn., Ill., Mo., Okla., Nev.).

M. atoka Girty (**127**—17–19). Length and width

PLATE 128

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–6. Cleiothyridina spp. 1, 2. C. hirsuta. V and S views. **3–5. C. sublamellosa.** V and D exts; D ext (x2). **6–8. C. orbicularis.** V, D, and S views. **9–20. Composita spp. 9–12. C. subtilita.** V, D, and S views; D int. **13–15. C. subquadrata** [Ill G S, M 1]. Ant, V, and D views. **16–20. C. trinucleа** [Ill G S, M 1]. V, D, Ant, and D views; D view of elongate individual. **21–24. Leptellina tennesseensis.** D Post (x3); D ext and int (x2); V ext (x2). **25–28. Sowerbyites triseptatus.** D int (x3); V int (x2); D exts (x1, x2). **29–33. Bimuria superba.** V ext and int; D ext; two views of D int (x2). **34–36. Plectodonta transversalis.** V and D exts; D int (x2) from Gotland. **37, 38. Ptychoglyptus virginiensis** (x2). V ext and int. **39–49. Sowerbyella spp. 39, 40. S. clarksvillensis.** V ext; D int (x2). **41–43. S. rugosa.** D exts (x1, x2); lab showing numerous D ints. **44–49. S. punctostriata.** D exts (x1, x3, x2); V and D ints (x2); slab showing numerous valves.

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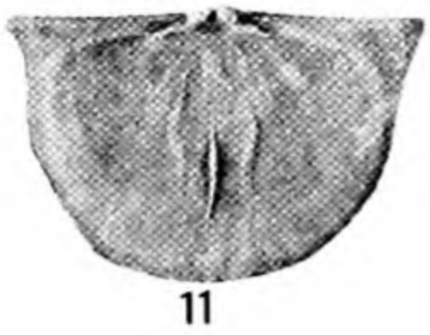

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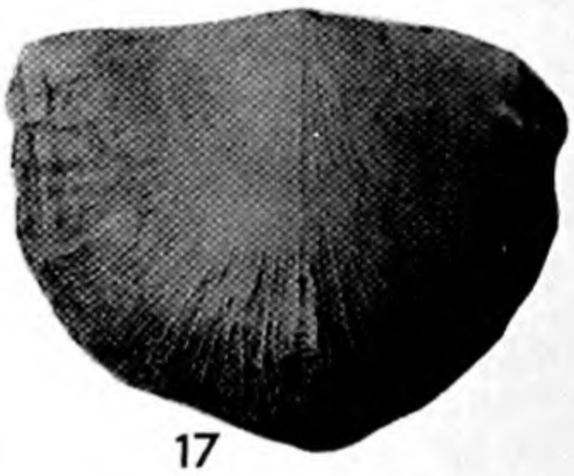

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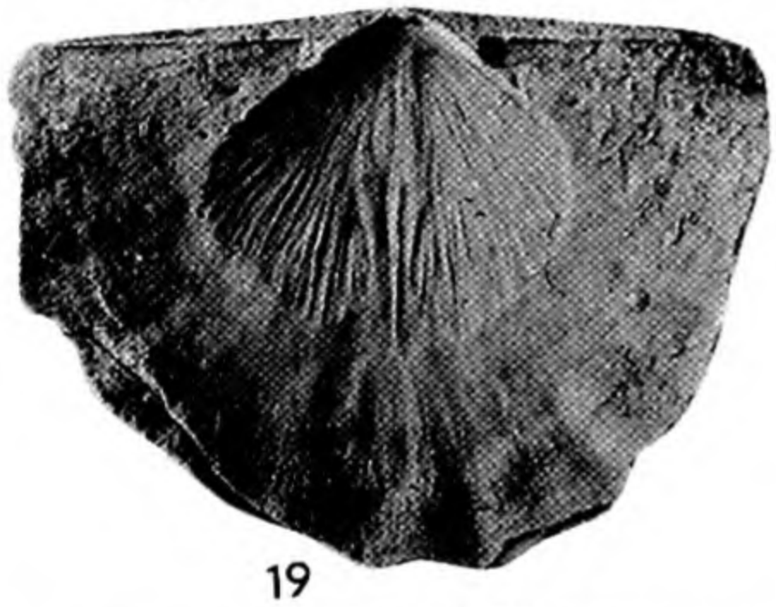

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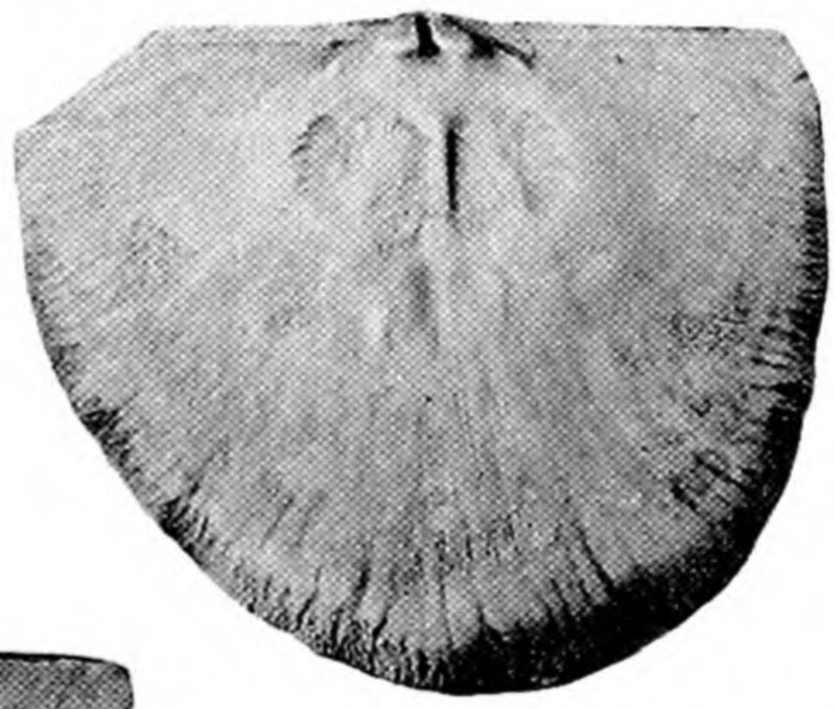

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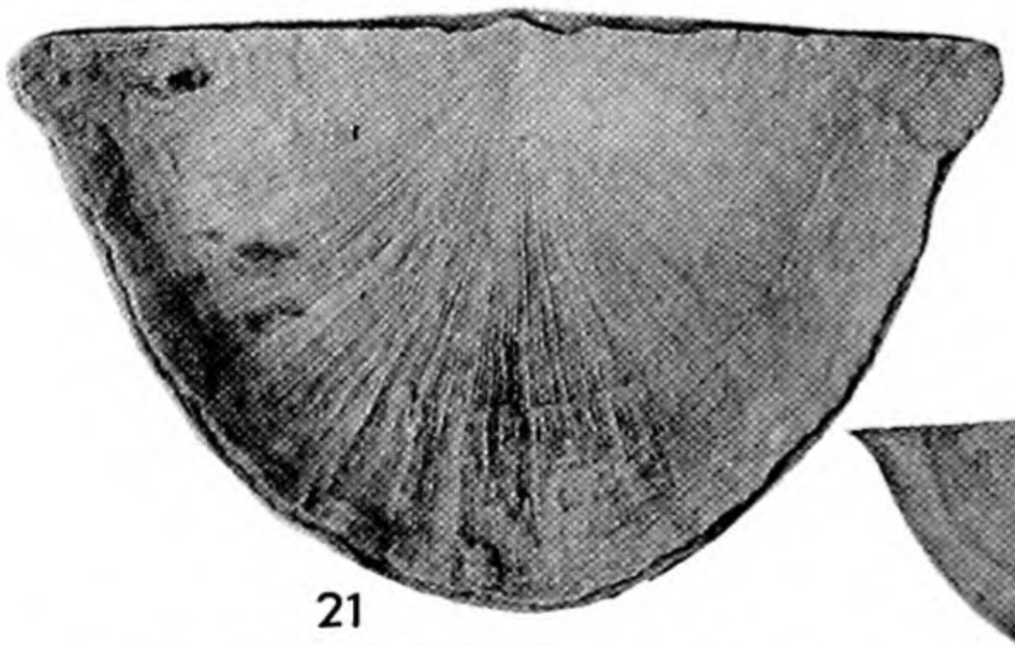

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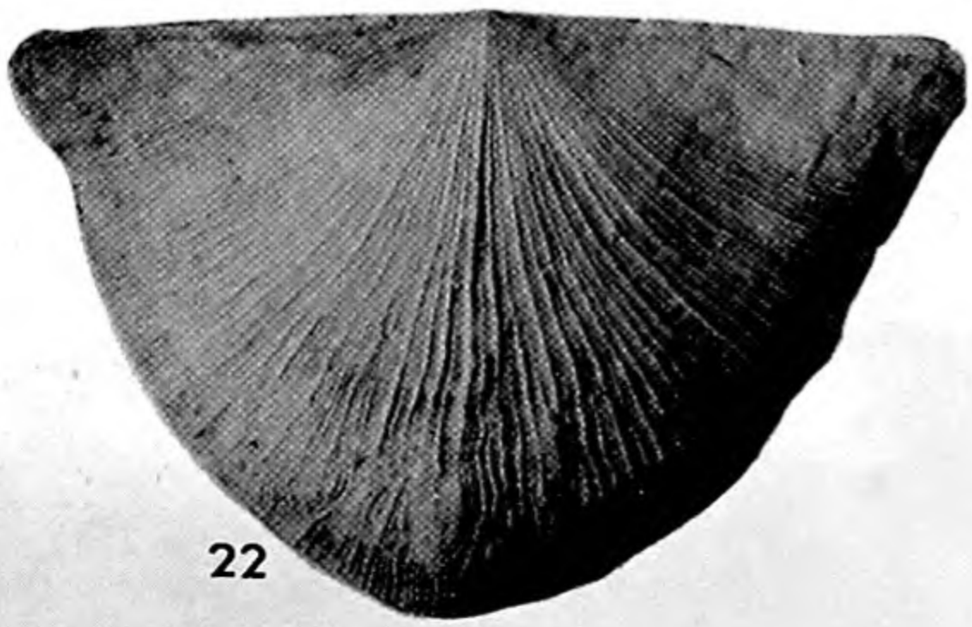

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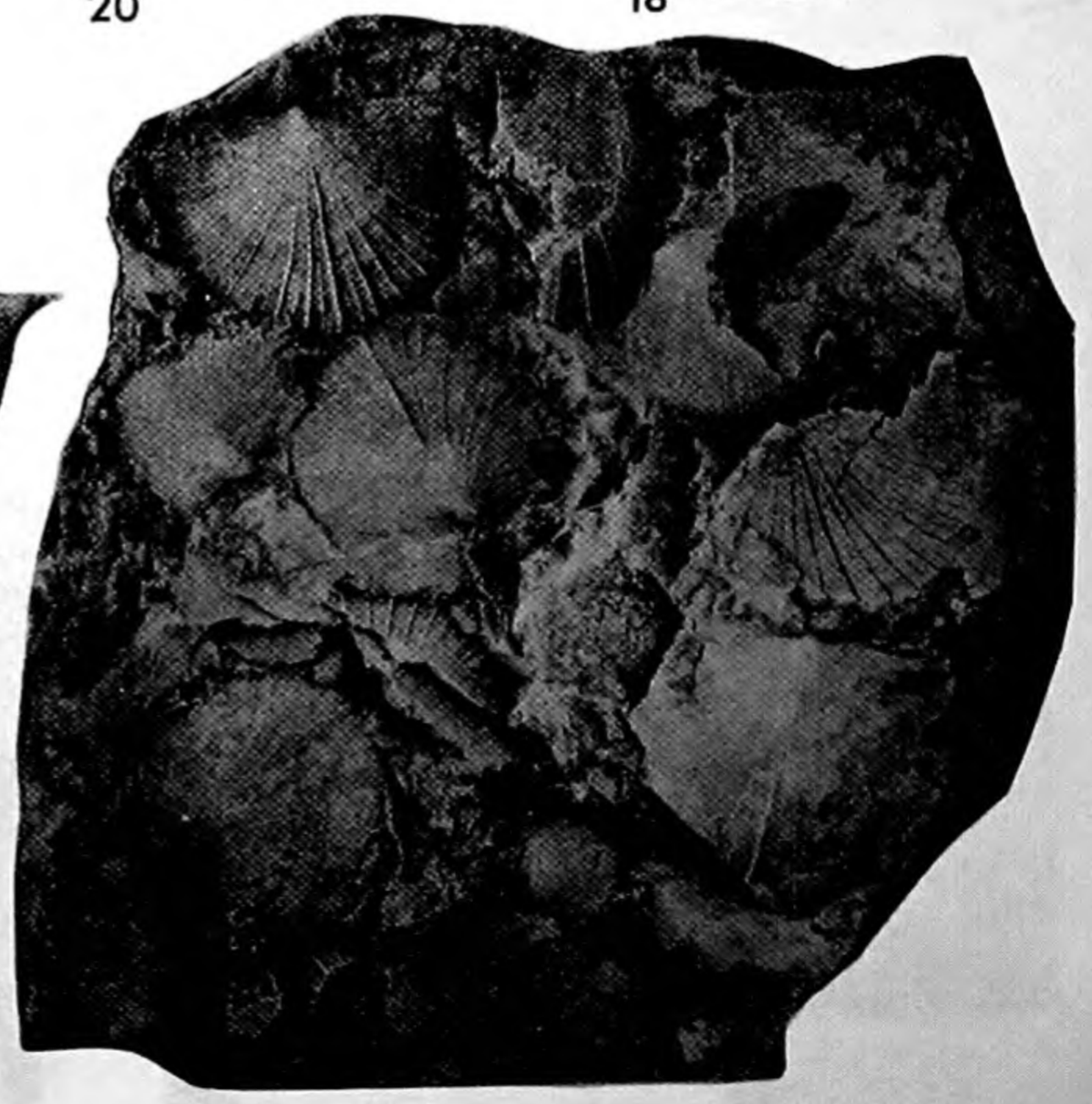

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about 19 mm; greatest width anterior to middle; beak angle about 90°; fold narrowly pinched anteriorly; ventral tongue long and acute. **L. Dev.:** W. Tenn., Okla.

M. arcuata Hall (**127**—20–22). Slightly larger than preceding, attaining a length and width of about 25 mm; fold less carinate and sulcus much shallower than preceding. **L. Dev.** (New Scotland): N. Y., Appalachians.

M. barrisi Hall (**127**—16). Large, longer than wide; fold low and broad; maximum width anterior to middle, beak angle about 75°; length about 28 mm, width 25 mm. **M. Dev.:** N. Y. (L. Hamilton).

M. robertsensis Merriam (**127**—23–25). Large, wider than long; width 38 mm, length 25 mm; sulcus broad and shallow; fold low; maximum width at about the middle; beak angle about 120°. **L. Dev.:** Nev. (Nevada).

M. nasuta (Conrad) (**127**—26, 27). Large; longer than wide; length about 44 mm; maximum width at middle; outline rhomboidal; fold narrowly rounded; beak angle about 90°. **Dev.** (Onondaga): Ont.: N. Y., Appalachians, Ohio, Ind., Ky.

CAMAROSPIRA Hall and Clarke 1893

(**C. eucharis* Hall). Like *Meristella* but having a spondylium in the ventral valve. **L.** and **M. Dev.** (Onondaga–Centerfield) (Ont.; N. Y., Mich., Ohio, Ind., Ky.).

***C. eucharis** (Hall) (**127**—28–31). **Onondaga:** Ont.; N. Y. (a closely related species in Hamilton (Centerfield) of Ont.; N. Y., Mich., Ohio, Ind., Ky.).

PENTAGONIA Cozzens 1846

(**Atrypa unisulcata* Conrad). Pentagonal in outline, dorsal valve the deeper of the two; ventral valve with broad sulcus; dorsal valve with strong fold marked medially by a narrow sulcus; ventral interior like *Meristella*; dorsal interior with ponderous thickened hinge plate bearing a deep pit in its posterior face. **L.** and **M. Dev.** (L. Onondaga to Centerfield) (Ont.; N. Y., Pa., Ohio. Ind., W. Tenn.).

***P. unisulcata** (Conrad) (**127**—37). Hexagonal to pentagonal in outline; dorsal valve with narrow fold having deep longitudinal depression extending nearly to front margin; profile showing valves of subequal but moderate depth. **Dev.** (Onondaga): Ont.; N. Y., Appalachians, W. Tenn.

P. bisulcata (Hall) (**127**—32–36). Much deeper than preceding, with a broader fold having a less deep and shorter median depression. **M. Dev.** (Centerfield and equivalents): Ont. (Hungry Hollow); N. Y., Pa., Ohio (Prout), Ind. (Beechwood).

ATHYRIS McCoy 1844

(**Terebratula concentrica* Buch). Subequally biconvex; transversely elliptical, subcircular to elongate-ovate; exterior smooth or lamellose; ventral valve sulcate, dorsal valve with low fold; foramen circular; ventral interior with short stout dental plates; dorsal interior with apically perforate hinge plate; median ridge low; jugum complex. **M. Dev.–Miss.** (all areas of outcrop).

A. cora Hall (**127**—38). Small, about 19 to 25 mm wide; slightly wider than long; outline subpentagonal, valves subequal in depth; sulcus shallow; fold low, defined at front only. **M. Dev.** (L. Hamilton): N. Y., Appalachians, Ind., Ky.

A. spiriferoides (Eaton) (**127**—39–43). Very large, subcircular, 38 mm or more wide; lamellose with numerous crowded lamellae. **M. Dev.** (U. Hamilton): N. Y., Appalachians.

A. angelica Hall (**127**—48–51). Small, 13 to 25 mm wide; subpentagonal in outline; sulcus deep; fold prominent on anterior half of valve; surface marked by regular fine concentric lamellae. **U. Dev.:** N. Y., Pa., Appalachians.

A. angelicoides Merriam (**127**—46, 47). Like preceding but generally smaller in size, more ventricose and with greater development of sulci on each side of fold. **U. Dev.:** Nev. (U. Devils Gate).

A. lamellosa (L'Eveillé) (**127**—44, 45). Large, transversely elliptical, with narrowly rounded sides and strong, distant concentric lamellae. **Miss.** (Burlington): Mississippi Valley.

CLEIOTHYRIDINA Buckman 1906

(**Athyris royssyii* Davidson). Subequally biconvex; outline transversely elliptical to longitudinally ovate; beak small; foramen circular; surface lamellose, lamellae bearing long slender spines; interior suggesting *Athyris* but with triangular hinge plate; primary lamellae attached to crura not only at their apices but for a short distance along their inner faces, not making the nooses peculiar to *Athyris* proper; they are broad and bladelike, narrowing beyond insertion of jugum; jugum is situated posteriorly; accessory lamellae are narrow near their origin, broaden and then taper again, having the shape of a sickle. **Miss.–Perm.** (Appalachians, Ind., Ky., Ill., Mo., Midcontinent, Ark., Tex.).

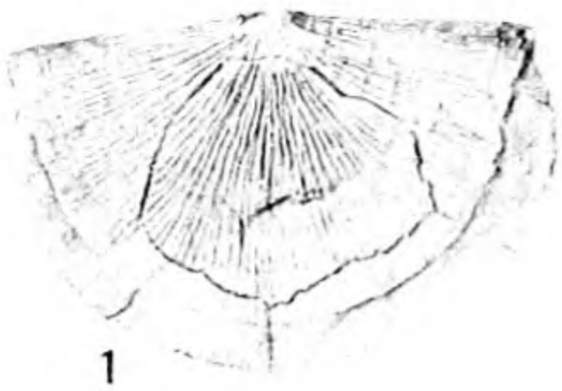
C. hirsuta (Hall) (**128**—1, 2). Small, subcircular, about 12 mm in length and width; valves subequally convex. **Miss.** (Warsaw-Ste. Genevieve): Ind., Ky., Ohio Valley.

C. sublamellosa (Hall) (**128**—3–5). Length and width about 19 mm; ventral valve shallow, dorsal strongly convex; specimens stripped of spines show

PLATE 129

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–7. Christiania subquadrata. D ext (x2); V ints (x2); D int (x2); V and D exts; Post view of D int (x2). **8, 9. Cymostrophia patersoni** [Pal N Y 4]. Two V exts. **10. Brachyprion leda** (x3). **11. Öpikina minnesotensis.** D int (x2). **12, 13. Protomegastrophia profunda.** D and V exts. **14–16. Öpikina septata.** D int (x2); V and D exts. **17–24. Rafinesquina** spp. **17, 18. R. nasuta.** V and D exts. **19–22. R. loxorhytis.** V and D ints; D and V exts. **23. R. deltoidea.** V ext. **24. R. trentonensis.** Slab showing numerous specimens.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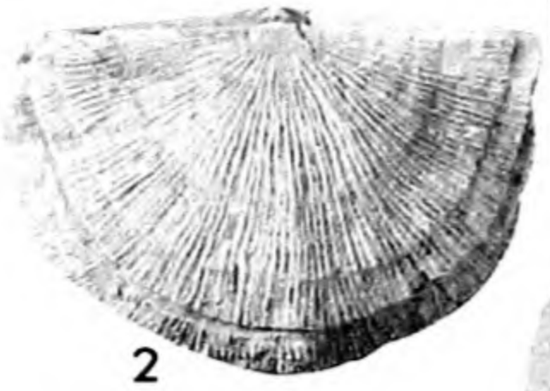
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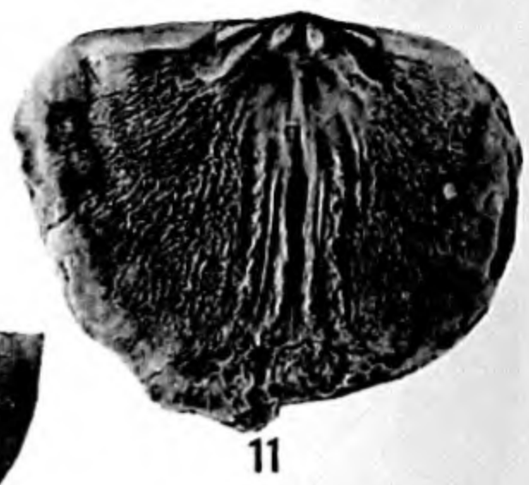
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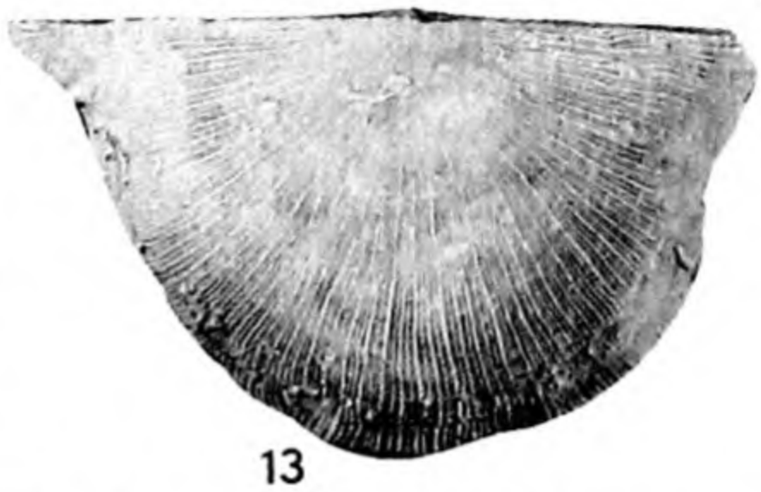
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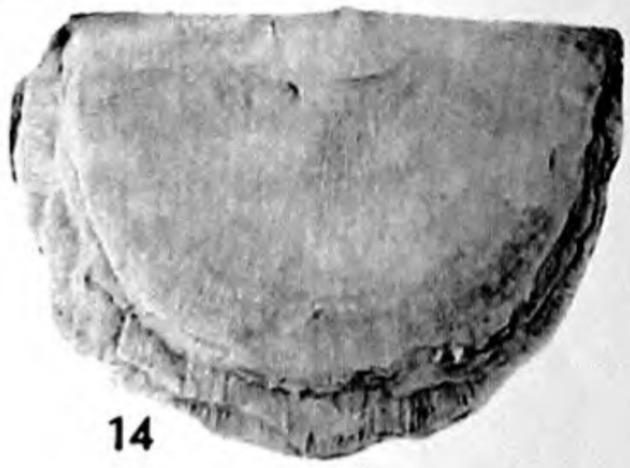
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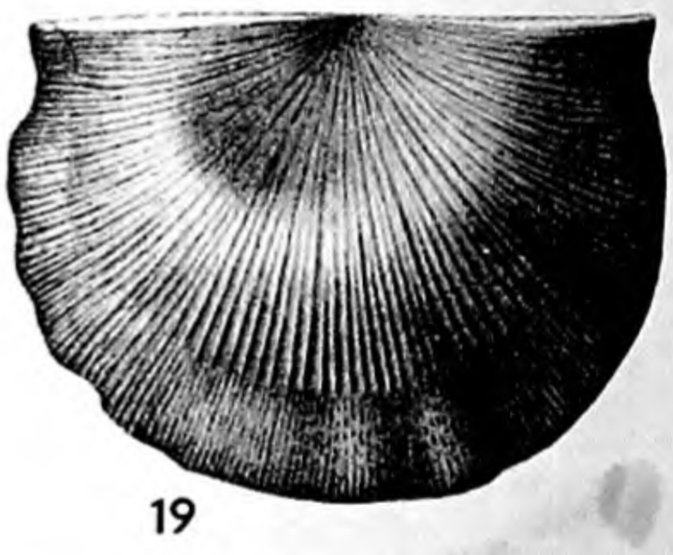
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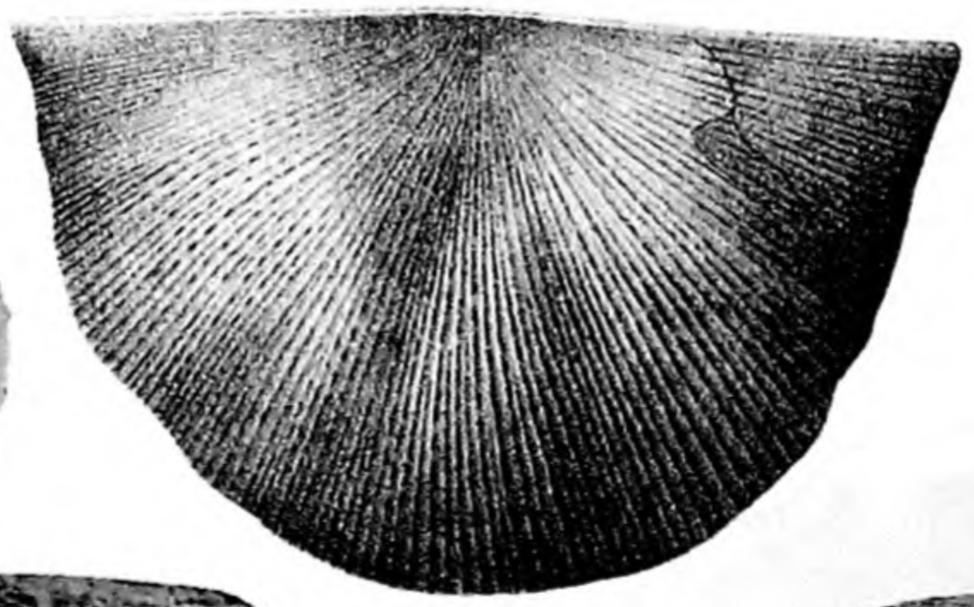
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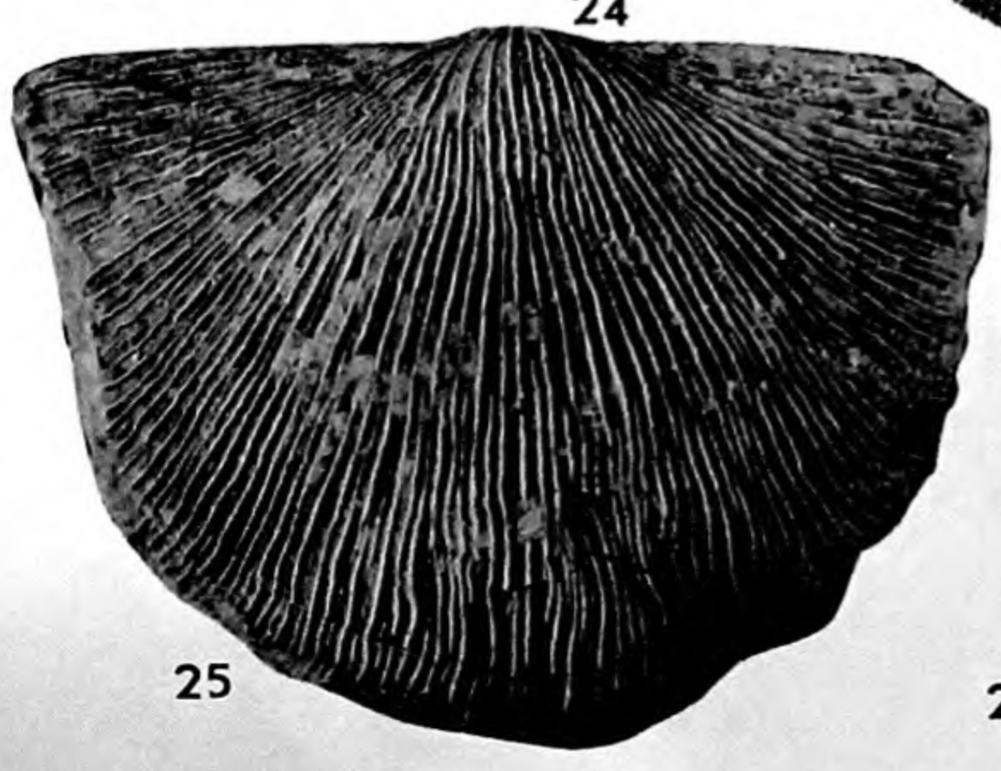
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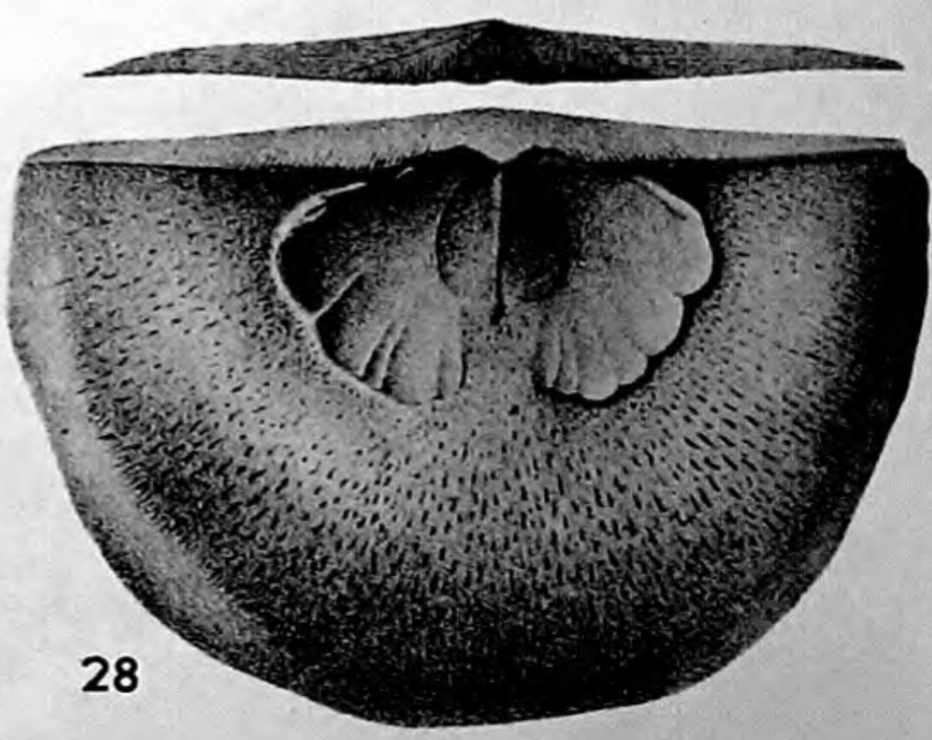
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a low fold and sulcus; if spines are present, fold and sulcus are more pronounced. **Miss.** (Chester): S. Appalachians, Ind., Ky., Mississippi Valley.

C. orbicularis (McChesney) (**128**—6–8). Attaining a length and width of 16 mm; valves strongly convex, the dorsal slightly more convex than the ventral. **Penn.:** Ind., Mo., Neb., Kan., Okla.

COMPOSITA Brown 1849

(**Spirifer ambiguus* Sowerby). Shells resembling *Athyris*, with circular foramen; surface smooth; strong ventral fold and dorsal sulcus; ventral interior with dental plates; dorsal hinge plate quadrate like that of *Athyris* but without median septum; jugum with broad saddle-shaped median plate often bilobed, bearing a process directed posteriorly and splitting into slender lamellae curved posterolaterally on each side of crura. **Miss.–Perm.** (all areas of outcrop).

C. trinuclea (Hall) (**128**—16–20). Variable, subtriangular in outline, valves subequally deep; fold low, sulcus shallow. **Miss.** (Salem–Chester): S. Appalachians, Ind., Ky., Mississippi Valley; Mex.

C. subquadrata (Hall) (**128**—13–15). Like preceding but in general somewhat larger, rounder in outline, and with stronger fold and sulcus. **U. Miss.** (Chester): S. Appalachians, Mississippi Valley, Ark., Okla.

C. subtilita (Shepard) (**128**—9–12). Small, subcircular, attaining a length-width of about 16 mm; fold and sulcus low, shown best on the anterior commissure. **Penn.:** Ill., Ia., Mo., Neb., Kan., Okla.

Pseudopunctate Articulata. Shells pseudopunctate.

STROPHOMENACEA. Pedicle threadlike, emerging from a tiny apical foramen or atrophied if shells lie free on sea bottom or are attached by more or less of ventral surface; pseudodeltidium and chilidium usually well developed; lophophore supported by short brachiophores.

LEPTELLINA Ulrich and Cooper 1936

(**L. tennesseensis*). Externally like *Sowerbyella* in outline, profile and ornamentation; dorsal valve with carinate median ridge, and elevated visceral area occupying the regions on each side of septum; cardinal process a simple ridge; chilidial plates present. **M. Ord.** (Chazy–Black River) (N. Y., Appalachians, Nev.).

***L. tennesseensis** U and C (**128**—21–24). **M. Ord.:** S. Appalachians.

SOWERBYITES Teichert 1937

(**S. medioseptata*). Externally like *Sowerbyella* but internally with a single strong median septum and a small lateral septum on each side; surface often lamellose. **M. Ord.** (Appalachians, Arbuckles of Okla.)

S. triseptatus Willard (**128**—25–28). Resembles *Sowerbyella* externally but usually shows wrinkled thin lamellae along margins; ventral interior with elongate diductor scars terminating in elevated callosities; dorsal interior with prominent median septum and a smaller secondary septum on each side. **M. Ord.** (post-Mosheim to pre-Athens): Appalachians.

SOWERBYELLA Jones 1928

(**Leptaena sericea* Sowerby). Transverse, wide-hinged, concavo-convex shells with fine costellae of unequal size, the smaller ones grouped between the larger ones; ventral interior with long diductor scars; dorsal interior with simple cardinal process fused with brachial processes to form an inverted and flattened V; two slightly divergent septa occupy middle of valve. **M.** and **U. Ord.** (all areas of outcrop).

S. punctostriata (Mather) (**128**—44–49). Attaining a width along the hinge of about 19 mm; convexity gentle; cardinal extremities slightly acute; costellae bearing small spines. **Ord.** (Trenton): Ont.; N. Y., U. Mississippi Valley.

S. clarksvillensis (Foerste) (**128**—39, 40). **Richmond** (Waynesville): Ohio Valley.

S. rugosa (Meek) (**128**—41–43). Width nearly twice the length; anterior often roughened by crowded lamellae; region just anterior to posterior margin marked by oblique wrinkles. **U. Ord.:** Appalachians, Ohio Valley (Eden).

BIMURIA Ulrich and Cooper 1942 (**105**—6)

(**B. superba*). Concavo-convex with surface covered with thin wavy lamellae; interior of ventral valve without dental plates; delthyrium covered; foramen small, apical; dorsal interior with two long septa, simple cardinal process and chilidial plates. **M. Ord.** (Lenoir–Chambersburg) (Pa., Va., Tenn., Ala.).

***B. superba** U and C (**128**—29–33). **M. Ord.:** S. Appalachians.

PLECTODONTA Kozlowski 1929

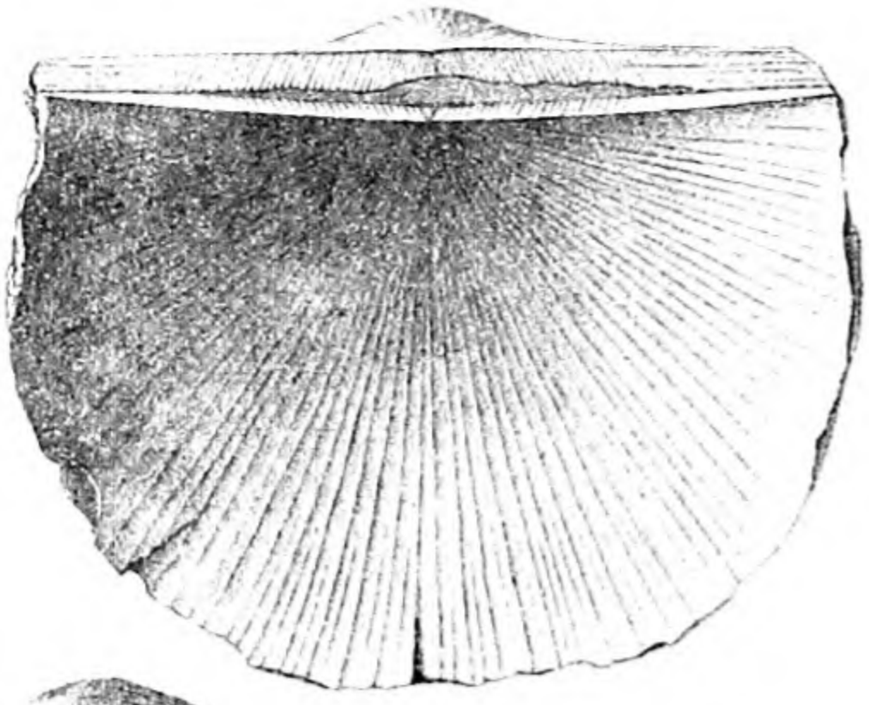
(**P. mariae*). Externally like *Sowerbyella* but internally with a denticulate hinge and four septa in the dorsal valve. **M. Sil.** (N. Y., Ohio, Ind., Ky., Tenn., Ala.).

P. transversalis (Dalman) (**128**—34–36). Hinge width about 19 mm; ventral valve strongly convex; dorsal valve deeply concave; cardinal extremities alate. **Niagaran:** N. Y., Ind., Ky., Ala.

PLATE 130

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–18. Strophomena spp. 1–5. S. planoconvexa. V, D, and S views; D and V ints. **6, 7. S. vicina.** V and D exts. **8–10. S. nutans.** V and D exts; V int. **11–14. S. neglecta.** D and V ints; D and V exts. **15–18. S. tennesseensis.** V int; S view; D and V exts. **19, 20. Strophonella punctulifera** [Pal N Y 8 (1)]. D ext; Imp D int. **21–24. Strophomena planumbona.** V and D exts; V and D ints. **25. Megastrophia concava.** V ext. **26–28. Strophonella ampla.** D and S views; V int.



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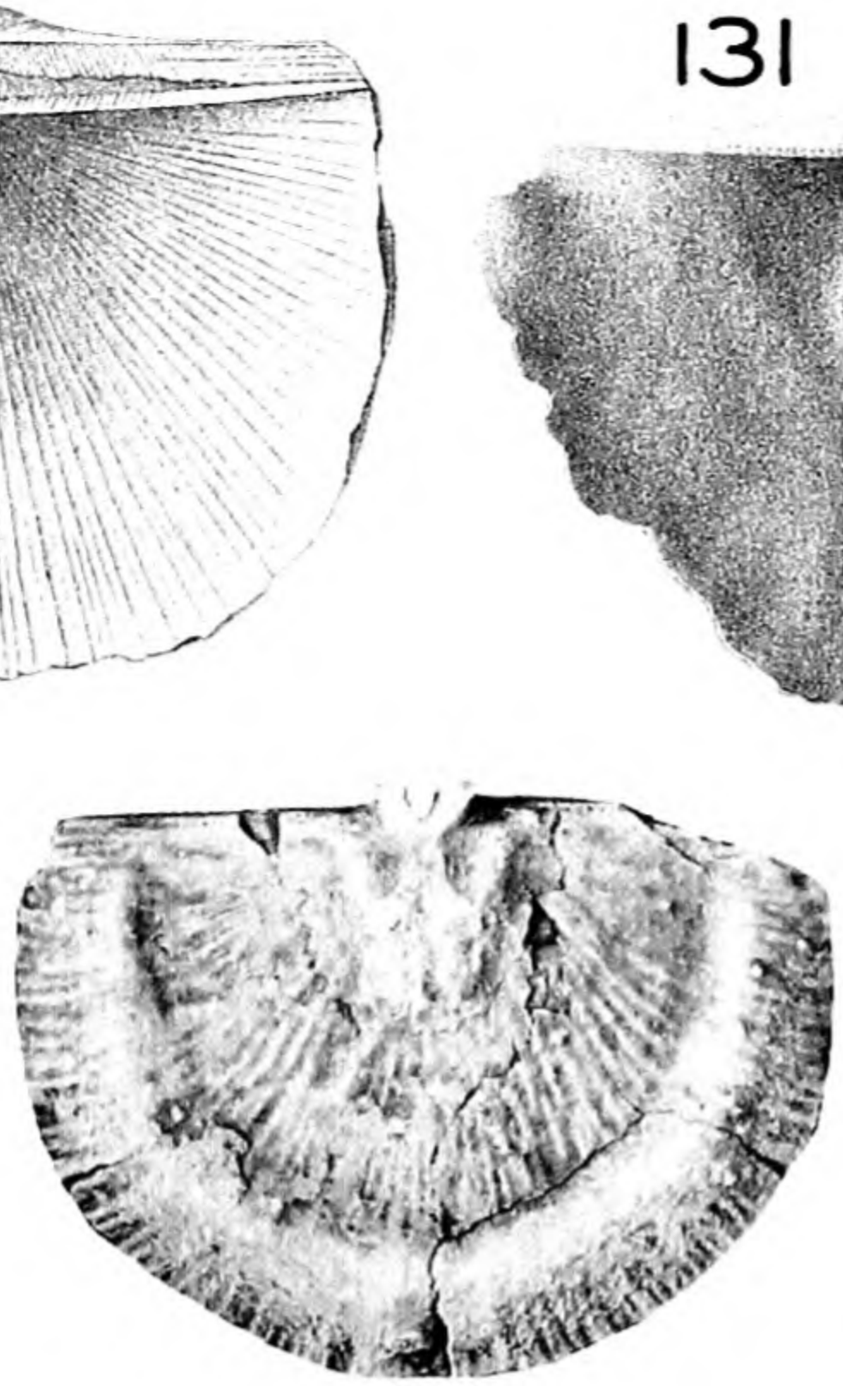

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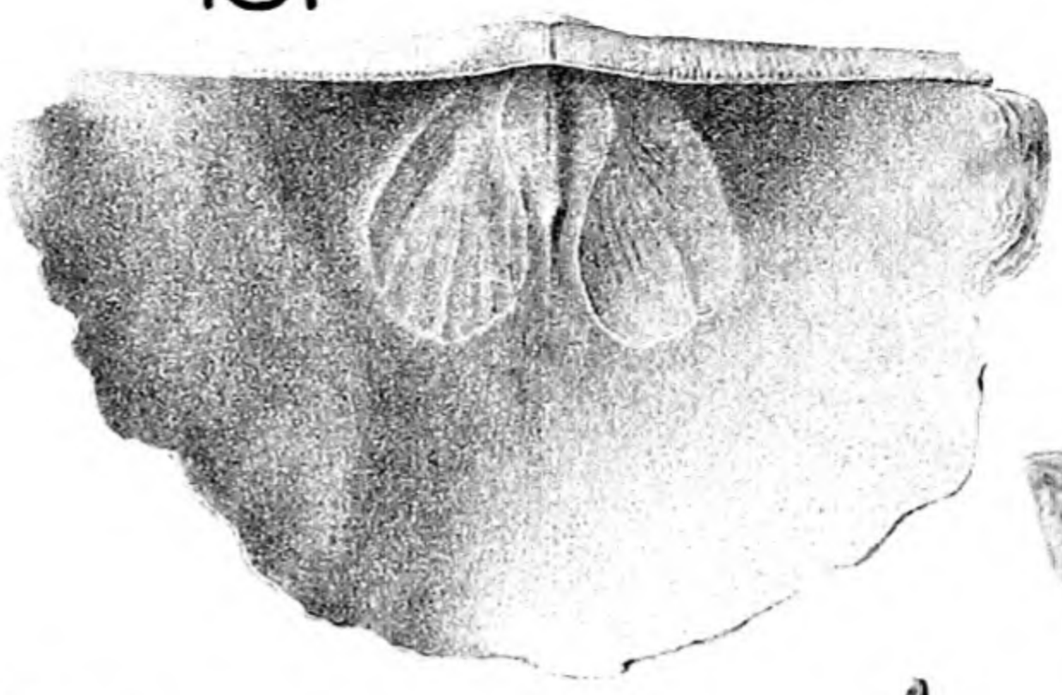

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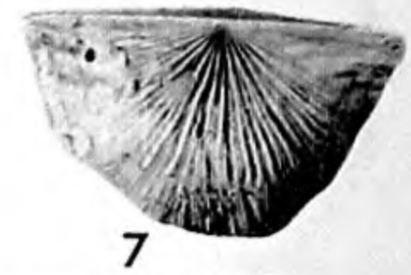

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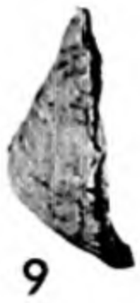

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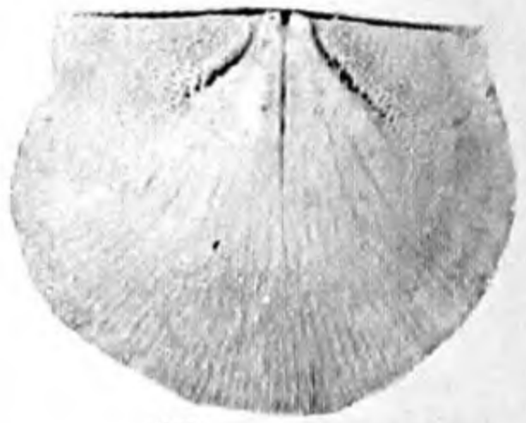

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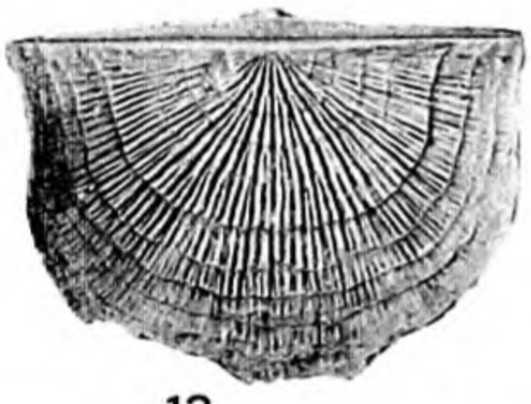

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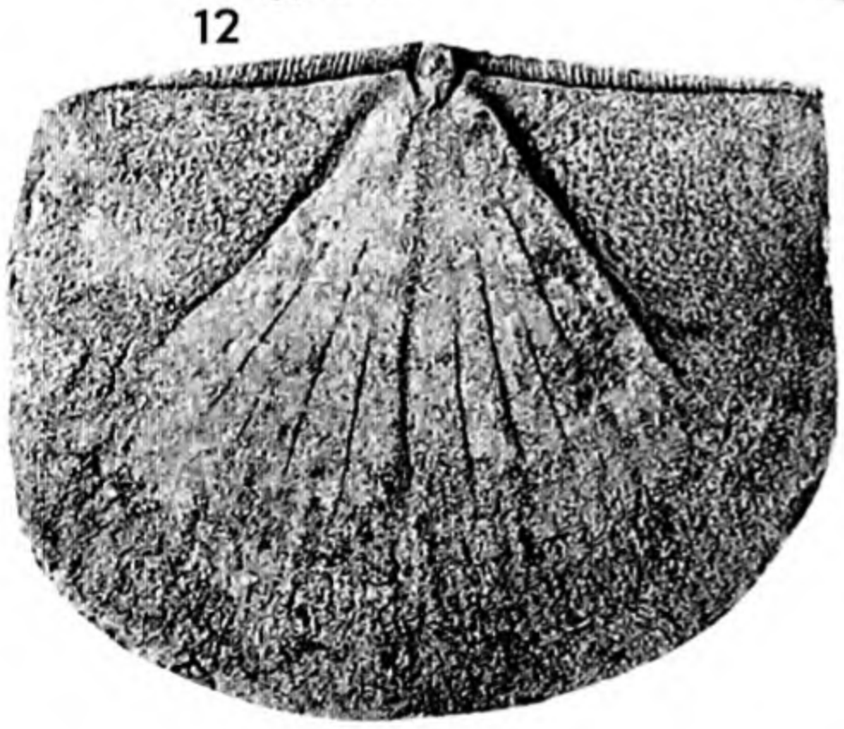

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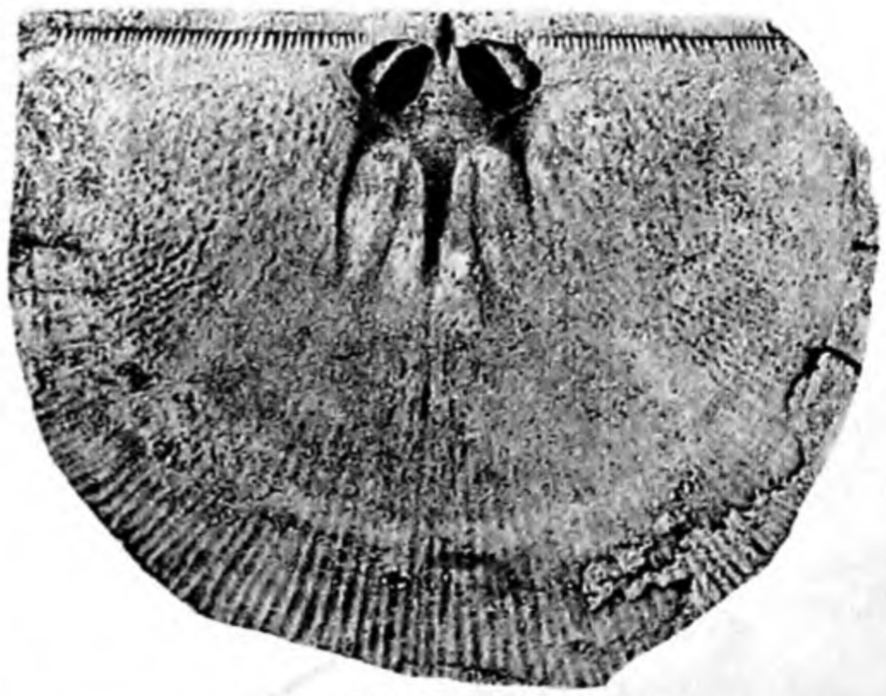

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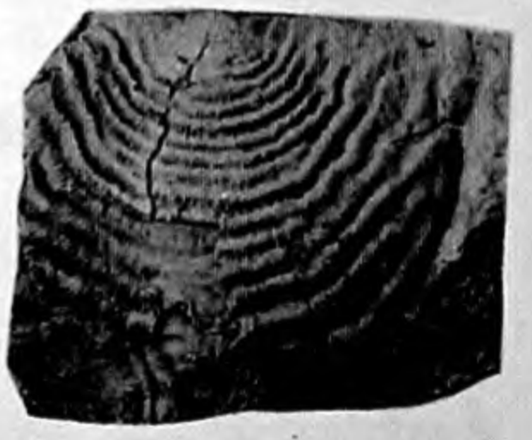

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PTYCHOGLYPTUS Willard 1928

(**P. virginiensis*). Transverse, with acuminate cardinal extremities; plano- to concavo-convex; finely costellate, with groups of fine costellae bounded by stronger ones and all undulating over zigzag wrinkles; dorsal interior similar to *Sowerbyites*. **M. Ord.** (Holston, Whitesburg) (Black River of Newf.; Va., Tenn., Ala.).

***P. virginiensis** Willard (**128**—37, 38). **M. Ord.** (Whitesburg): S. Appalachians.

RAFINESQUINA
Hall and Clarke 1892 (**106**—9)

(**Strophomena alternata* Emmons). Generally large with concave or flat dorsal valve and convex ventral valve; foramen apical; palintrope well developed; pseudodeltidium convex; costellate with costellae of unequal size, the fine ones usually separated into groups by the large ones; shell substance with coarse pseudopunctae arranged in longitudinal rows; ventral valve with large flabellate muscular area; dorsal valve with bilobed cardinal process and short median ridge. **M.** and **U. Ord.** (widespread throughout N. America).

R. trentonensis Conrad (**129**—24). Small, wider than long with the width along the hinge attaining about 25 mm; ventral valve flat or gently concave; ventral convexity gentle. **M. Ord.** (Trenton): Ottawa Valley; N. Y., Appalachians, U. Mississippi Valley.

R. deltoidea (Conrad) (**129**—23). Subtriangular in outline; hinge 25 mm or more wide; cardinal extremities alate; valves geniculated 16 mm anterior to beak at about 110°; geniculated part narrowly folded medially. **M. Ord.** (Trenton): Ottawa Valley; N. Y.

R. ponderosa Hall. Large, generally wider than long with heavy shells; geniculation takes place about 31 mm from beak; angle of geniculation about 135°. **U. Ord.** (Maysville): N. Y., Ohio Valley, W. Tenn.

R. nasuta (Conrad) (**129**—17, 18). Smaller than preceding, with thinner shell; median anterior narrowly folded. **U. Ord.** (Maysville, Pulaski): N. Y., Ohio.

R. loxorhytis (Meek) (**129**—19–22). Differs from *R. ponderosa* by its greater size and alate cardinal extremities. **U. Ord.** (Richmond): Ohio, Ind., Ky.

ÖPIKINA Salmon 1943

(**Ö. septata*). Generally small concavo-convex shells, more or less strongly geniculated anteriorly; surface finely multicostellate; ventral interior with large flabellate muscular area; dorsal interior with bilobed cardinal process and five more or less strong septa associated with the adductor field; shell substance finely pseudopunctate. **M. Ord.** (Chazy–Trenton) (Ottawa Valley; Appalachians, Mississippi Valley, Tenn., Arbuckles of Okla.).

***Ö. septata** Salmon (**129**—14–16). Small, alate, hinge width about 22 mm, length 13 mm; anterior geniculated portion short. **M. Ord.** (Lebanon): Appalachians, Tenn.

Ö. minnesotensis (Winchell) (**129**—11). Small, resembling preceding but not alate; ventral muscular field larger and dorsal septa less strongly developed. **L. Trenton:** U. Mississippi Valley.

STROPHOMENA Blainville 1825

(**Leptaena planumbona* Hall). Internally like *Rafinesquina* but with a concave ventral valve and convex dorsal valve. **M.** and **U. Ord.** (widespread throughout N. America).

S. tennesseensis Willard (**130**—15–18). Large, slightly wider than long; ventral valve gently concave, dorsal valve moderately convex; outline longitudinally semi-elliptical with straight sides and narrowly rounded anterior; ventral interior with elevated peripheral rim. **M. Ord.** (Ottosee): Appalachians of Va. and Tenn.

S. vicina Foerste (**130**—6, 7). Fairly large, 31 mm along hinge; cardinal extremities acute; lateral margins sloping inward; anterior margin narrowly rounded; ventral valve slightly concave; dorsal valve only gently convex. **Trenton:** Ky., W. Tenn.

S. planoconvexa Hall (**130**—1–5). About 31 mm wide and 25 mm long; sides slightly oblique; concavity and convexity gentle; costellae strong. **Maysville:** Ohio Valley.

S. planumbona Hall (**130**—21–24). About 25 mm wide and 19 mm long; sides nearly straight; ventral valve most concave in mid-region; dorsal valve fairly strongly convex in anterior half; ventral muscular area small, with thickened rim. **M. Richmond:** Ohio Valley.

S. neglecta James (**130**—11–14). Large, 38 mm wide; ventral valve deeply concave; dorsal valve strongly convex, the convexity starting about 13 mm anterior to beak. **Richmond:** Ohio Valley.

S. nutans (Meek) (**130**—8–10). About 28 mm wide, deeply concave; anterior pinched into a narrow fold. **Richmond:** Anticosti; Ohio Valley, Ill.; Man.

CHRISTIANIA Hall and Clarke 1892

(**Leptaena subquadrata* Hall). Elongate to quadrate in outline, concavo-convex in profile; interarea short, pseudodeltidium convex, foramen apical; surface

PLATE 131

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–4. Megastrophia concava. D and S views; V int [Pal N Y 4]; D int. **5, 6. Strophеodonta erratica.** V and D exts. **7–11. Strophonelloides reversus.** D, V, and S views; D and V ints. **12–14. Strophеodonta demissa.** D ext; D and V ints. **15–17. Protoleptostrophia perplana.** Imp V int; V ext; Post portion of D int (x2). **18, 19. Leptostrophia magnifica.** Imp V and D ints. **20, 21. Sulcatostrophia camerata.** V and D exts. **22, 23. Nervostrophia nervosa.** Imp D and V ints. **24, 25. Nervostrophia rockfordensis.** V and D ints. **26–28. Rhytistrophia beckii.** V int; two imperfect Vv showing ext.

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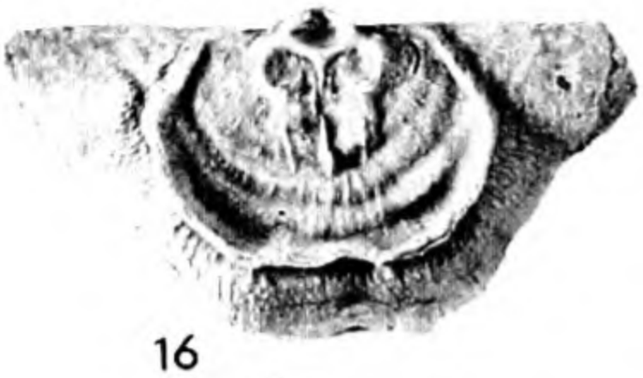
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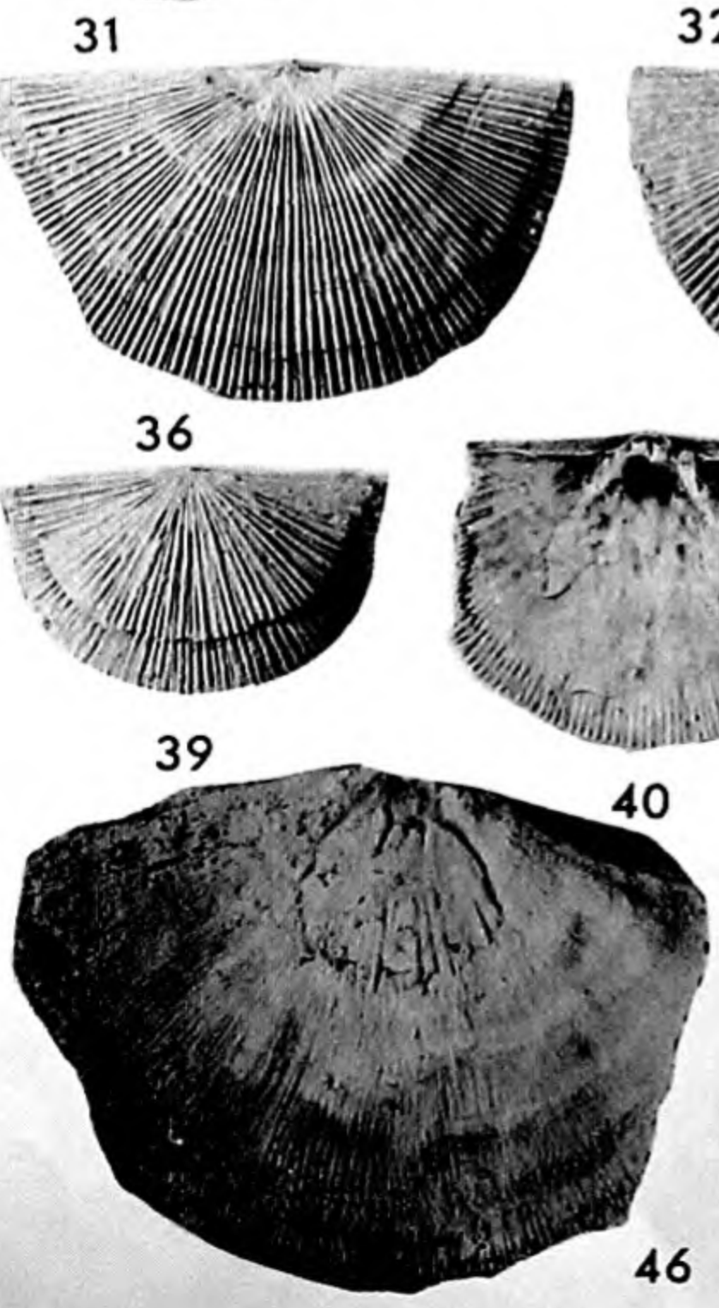
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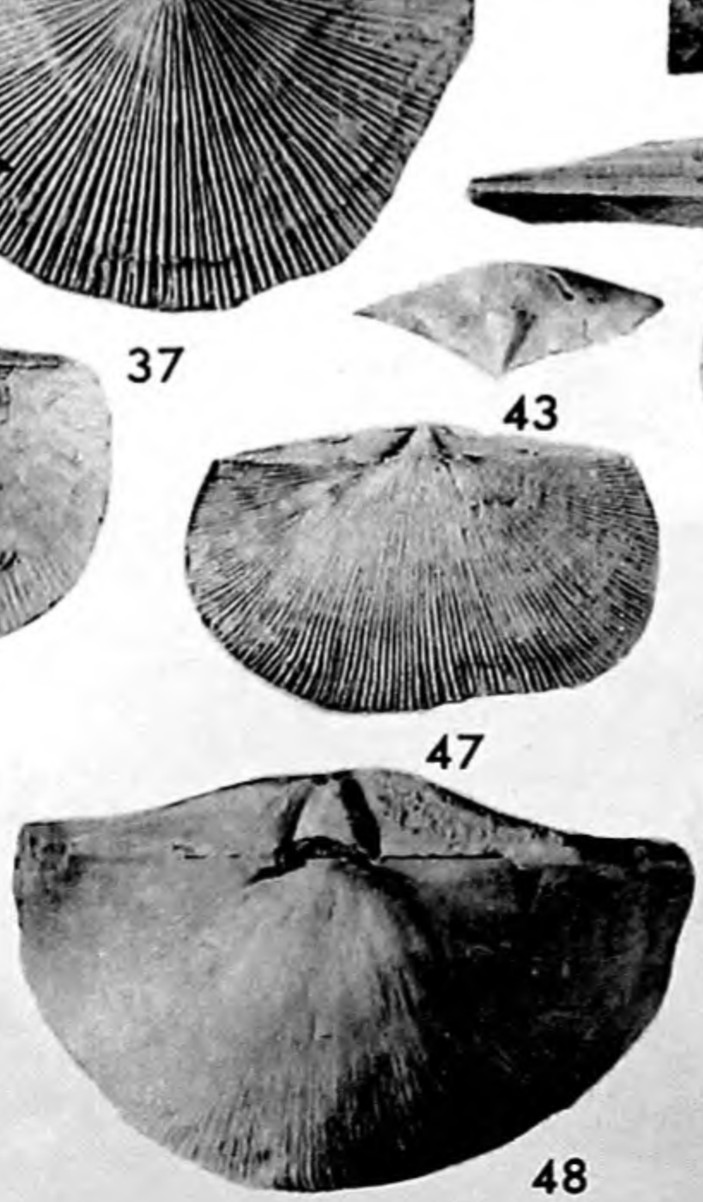
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smooth or with fine radii; ventral interior with long pallial sinuses; dorsal interior with bilobed cardinal process and four elongate ridges extending to front margin. **M.** and **U. Ord.** (Newf.; Que.; S. Appalachians).

***C. subquadrata** (Hall) (**129**—1–7). Elongate, hinge narrower than greatest width, which is located in anterior half; length about 13 mm, width 10 mm. **M. Ord.** (Lenoir): S. Appalachians.

BRACHYPRION Shaler 1865

(**Strophomena leda* Billings). Suggesting *Rafinesquina* in profile, outline, and ornamentation but with a partly denticulate hinge. **Sil.** to **L. Dev.** (Newf.; Anticosti; N. B., Que.; N. Y., Appalachians, Midwest, W. Tenn., Okla.).

***B. leda** (Billings) (**129**—10). **M. Sil.:** Newf.; Anticosti.

STROPHONELLA Hall 1879

(**S. semifasciata*). Like *Strophomena* in profile, outline, and ornamentation but with a partly denticulate hinge. **M. Sil.** to **Dev.** (Onondaga) (N. B., Que., Ont.; N. Y., Appalachians, Ohio, W. Tenn., Mo., Okla., Great Basin).

S. punctulifera (Conrad) (**130**—19, 20). About four-fifths as wide as long; subsemicircular; strongly geniculate about 19 mm anterior to beak. **L. Dev.** (Helderberg): Arctic; N. B., Que.; Me., N. Y., Appalachians, W. Tenn.

S. ampla (Hall) (**130**—26–28). Large, width up to 75 mm, length 50 mm; subrectangular in outline; dorsal valve strongly convex anteriorly; muscular area of ventral valve large, flabellate with thickened margins. **Dev.** (L. Onondaga): Ont.; N. Y., Ohio, Ind.

PROTOMEGASTROPHIA Caster 1939

(**Leptaena profunda* Hall). Deeply concavo-convex; hinge line denticulate; ventral muscular field like *Megastrophia*. **M. Sil.** (Appalachians, Midwest).

***P. profunda** (Hall) (**129**—12, 13). **M. Sil.:** N. Y., Ind., W. Tenn.

MEGASTROPHIA Caster 1939

(**Strophodonta concava* Hall). Large; deeply concavo-convex; hinge completely denticulate; large costellae separate groups of smaller ones and all cancellated by raised concentric lines; ventral muscular field comparatively small; dorsal cardinal process bilobed, ponderous, adductor scars on elongate elevated platform. **M. Dev.** (Ont.; N. Y., Appalachians, Ohio, Ind., Ill., Mo.).

M. hemisphaerica (Hall). Similar to *M. concava* but usually more convex and with costellae nearly uniform. **Dev.** (Schoharie, Onondaga) (Ont.; N. Y., Ohio, Ind., Ky.).

***M. concava** (Hall) (**130**—25; **131**—1–4). Large, alate, with hinge forming widest part; length four-fifths of hinge width; ventral valve very convex; costellae arranged in groups of fine ones separated by stronger ones, all cancellated by fine concentric fila. **M. Dev.** (Hamilton): Ont.; N. Y., Pa., Mich., Ind., Ky., Ill., Mo.

CYMOSTROPHIA Caster 1939

(**Leptaena stephani* Barrande). Large, thin-shelled, concavo-convex; costellae unequal in size, undulating over irregular corrugations; hinge nearly completely denticulate. **M. Dev.** (Ont.; N. Y., Ill.).

C. patersoni (Hall) (**129**—8, 9). **M. Dev.:** Same distribution as genus.

STROPHEODONTA Hall 1852

(**Strophomena demissa* Conrad). Concavo-convex in profile, costellate to costate; pseudodeltidium fused with interarea; apical foramen sealed; ventral muscular area broadly flabellate; dorsal valve with bilobed cardinal process; hinge completely denticulate. **Dev.** (Onondaga–Chemung) (widespread throughout N. America).

***S. demissa** (Conrad) (**131**—12–14). Width 43 mm, length 37 mm, subrectangular in outline; umbonal region strongly costellate, flanks and margins more finely costellate. **M. Hamilton:** N. Y., Pa. (Widely but incorrectly identified at many horizons in **M. Dev.**)

S. erratica Winchell (**131**—5, 6). Small, broader than long, hinge forming widest part, cardinal extremities acuminate; ventral valve moderately convex; dorsal valve flat to moderately concave; costae strong and broadly angular. **Traverse:** Mich. (Similar appearing species in Ia.).

STROPHONELLOIDES Caster 1939

(**Strophodonta reversa* Hall). Suggesting *Strophedonta* in ornamentation but convexi-concave; hinge completely denticulate. **U. Dev.** (N. Y., Appalachians, Ia., Mo., N. Mex., Ariz., Nev.).

***S. reversus** (Hall) (**131**—7–11). **U. Dev.:** N. Y., Ia., Ariz., N. Mex.

PLATE 132

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Pholidostrophia nacrea. D and V ints; D ext. **4–11. Douvillina spp. 4–7. D. arcuata.** D and V ints; V and D exts. **8–11. D. inaequistriata.** V and D exts; D int (x2); V int. **12, 13. Douvillinella variabilis.** D ext and int. **14, 15. Dactylogonia geniculata.** V ext; D int. **16–29. Leptaena spp. 16–22. L. "rhomboidalis."** 16–20 (Dev); D int; V ext; V int; V and D exts. 21, 22 (Sil); D and S views. **23–25. L. richmondensis.** V and D exts; D int. **26, 27. L. unicostata.** V ext; D int. **28, 29. L. analoga** [Ill G S, M 1]. V and D exts. **30–33. Holtedahlina sulcata.** V int; V and D exts; D int (x2). **34, 35. Leptaenisca concava.** D int and ext. **36–40. Fardenia subplana.** D, V, and Post views of a large shell; D view of small valve; D int. **41, 42. Liljevallia adnascens** (x2). D ext; two V ints. **43–51. Schuchertella spp. 43–45. S. perversa.** Post, V, and D views. **46–48. S. desiderata.** Imp V int; D ext of small specimen; posterodorsal view of Int F. **49–51. S. woolworthana.** D ext; V and D ints.

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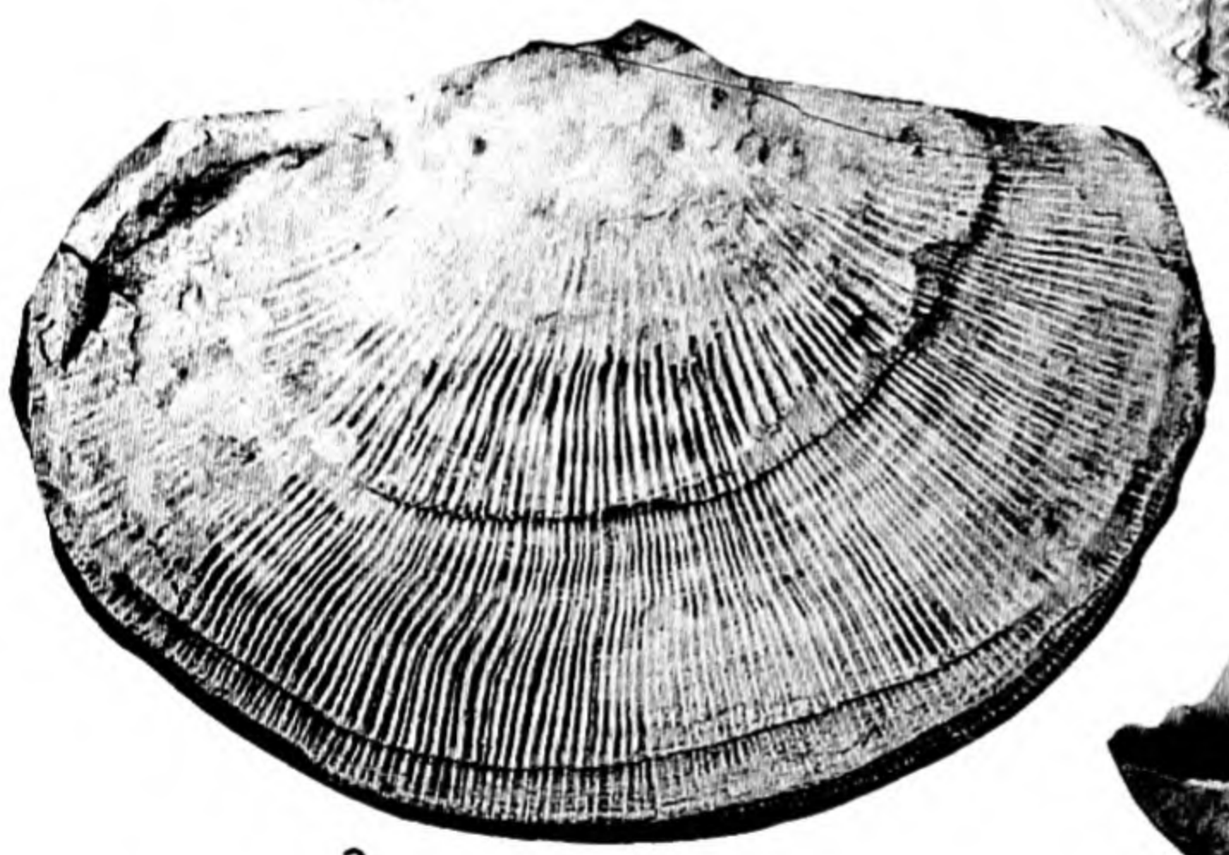

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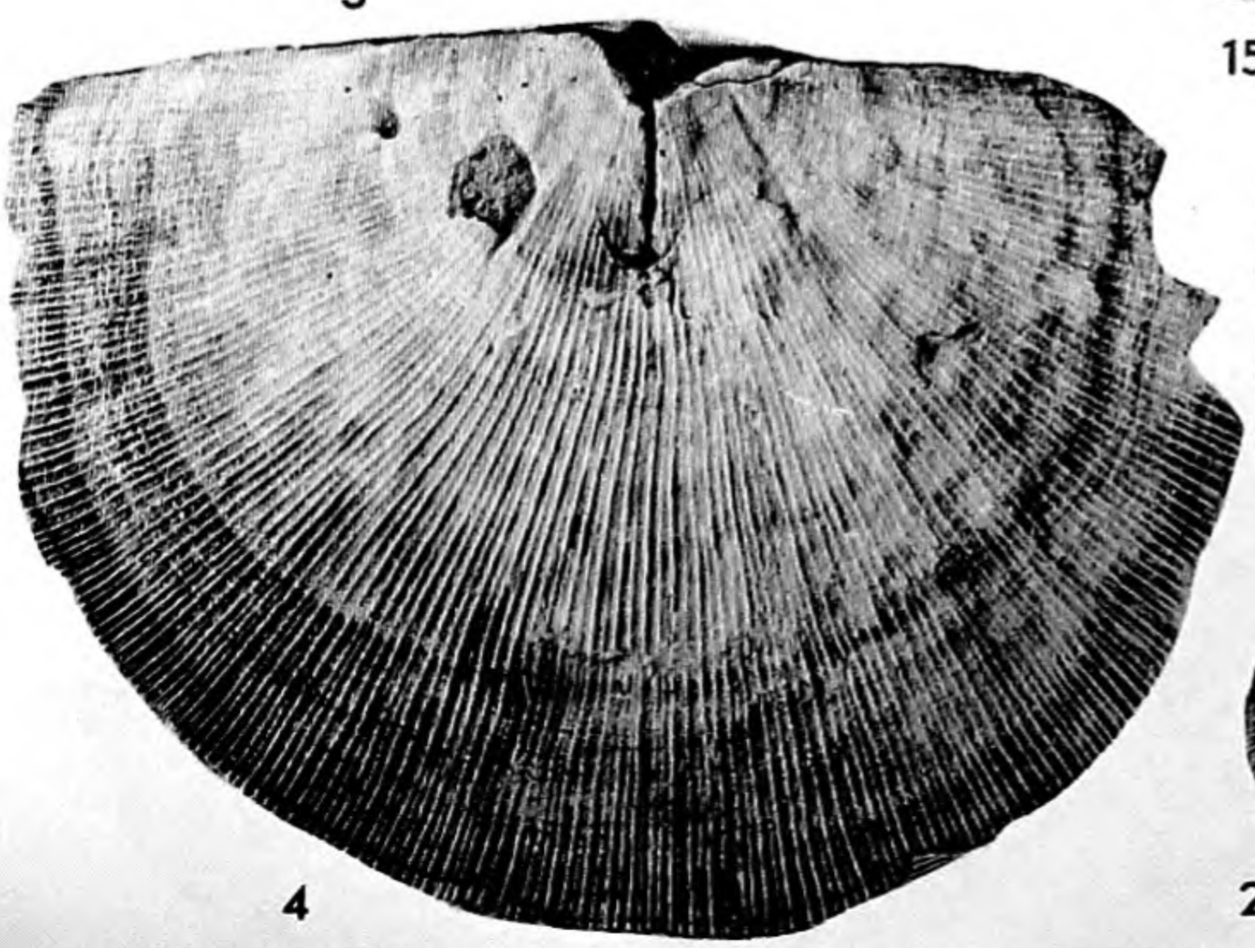

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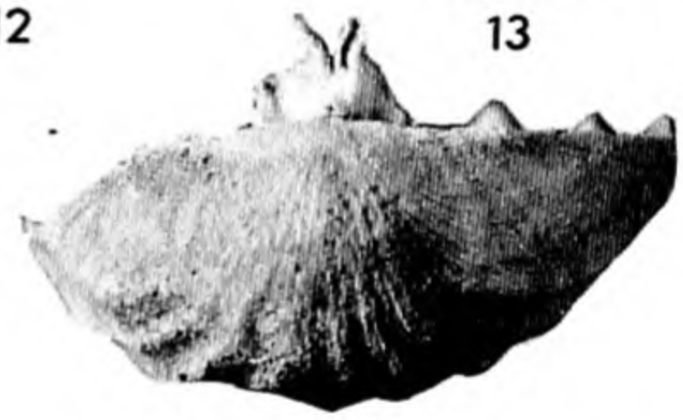

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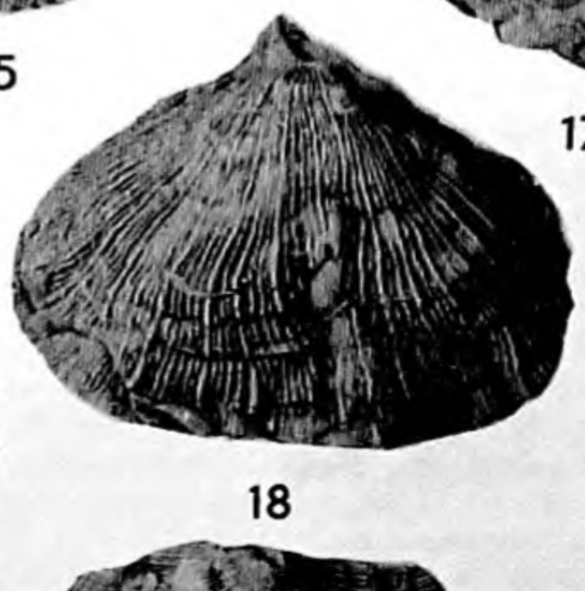

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LEPTOSTROPHIA Hall and Clarke 1892

(**Strophodonta magnifica* Hall). Large with completely denticulate hinge; slightly convex ventral valve and concave to nearly flat dorsal valve; ventral muscular field narrow posteriorly but broadly flabellate anteriorly; dorsal valve with large bilobed cardinal process, the lobes distant; adductor field large, central. **L. Dev.** (Oriskany) (Que., Ont.; N. Y., Appalachians, Mississippi Valley, W. Tenn.).

***L. magnifica** (Hall) (**131**—18, 19). **Oriskany:** Que., Ont.; N. Y., Appalachians.

PROTOLEPTOSTROPHIA Caster 1939

(**Strophomena blainvillii* Billings). Smaller than *Leptostrophia* with nearly flat dorsal valve; ventral musculature like *Leptostrophia*; dorsal interior with small bilobed cardinal process and small posteriorly located adductor field. **L.** and **M. Dev.** (Que., Ont.; N. Y., Appalachians, Mich., Ohio, Mississippi Valley).

P. perplana (Conrad) (**131**—15–17). Wider than long, about 38 mm wide and 31 mm long; cardinal extremities slightly alate; ventral valve often with narrow impressed line extending from beak to beyond middle; valves finely multicostellate. **Hamilton:** Ont.; N. Y., Appalachians, Mich., Ohio, Ind., Ill., Mo.

RHYTISTROPHIA Caster 1939

(**Strophodonta beckii* Hall). Like *Leptostrophia* internally but shell thrown into strong concentric wrinkles as in *Leptaena*. **Dev.** (Helderberg to Onondaga) (Que.; N. Y., Appalachians, W. Tenn., Ill., Mo., Okla.).

***R. beckii** (Hall) (**131**—26–28). Range and distribution same as genus.

NERVOSTROPHIA Caster 1939

(**Strophomena nervosa* Hall). Large, flat shells like *Leptostrophia* but surface ornamented by costellae, the principal ones being short and interrupted. **Dev.** (Tully through Chemung) (N. Y., Appalachians, Ia., Great Basin).

***N. nervosa** (Hall) (**131**—22, 23). **Chemung:** N. Y., Pa.

N. rockfordensis Fenton and Fenton (**131**—24, 25). **U. Dev.:** Ia. (Hackberry).

SULCATOSTROPHIA Caster 1939

(**Leptostrophia camerata* Fenton and Fenton). Interior and ornamentation like *Nervostrophia* but strongly concavo-convex. **U. Dev.** (N. Y., Appalachians, Ia., Great Basin).

***S. camerata** (F and F) (**131**—20, 21). **U. Dev.:** Ia. (Hackberry).

PHOLIDOSTROPHIA Hall and Clarke 1892

(**Strophomena* [*Strophodonta*] *nacrea* Hall). Generally small shells, concavo-convex in profile with the interior of *Strophcodonta* but a smooth and pearly-appearing shell. **M. Sil., Dev.** (Tully) (widespread throughout N. America).

***P. nacrea** (Hall) (**132**—1–3). **Hamilton:** Ont.; N. Y., Pa.

DOUVILLINA Oehlert 1887

(**Orthis dutertrei* Murchison). Concavo-convex, ornamentation like *Megastrophia*; ventral interior with elevated margin; dorsal interior with two elevated plates arising from floor in front of adductor field. **Dev.** (Onondaga through Chemung) (Ont.; N. Y., Appalachians, Mich., Ohio. Ind., Ariz.).

D. inaequistriata (Conrad) (**132**—8–11). About 25 mm wide along hinge; cardinal extremities acute, alate; valves strongly concavo-convex; costellae neatly arranged in groups of fine ones separated by distant stronger ones. **M. Dev.** (Hamilton–Tully): Ont.; N. Y., Appalachians, Mich., Ohio, Ind.

D. arcuata (Hall) (**132**—4–7). **U. Dev.:** Ia. (Hackberry)

DOUVILLINELLA Spriestersbach 1925

(**Stropheodonta* (*Douvillina*) *filifer* Schmidt). Internally like *Douvillina* but with anteriorly concave ventral valve and convex dorsal valve. **U. Dev.** (Chemung) (N. Y., Ia.):

D. variabilis (Calvin) (**132**—12, 13). **U. Dev.:** Ia. (Independence).

DACTYLOGONIA Ulrich and Cooper 1942

(**D. geniculata*). Shells attaining 25 mm or slightly more in width; multicostellate but unwrinkled; strongly geniculated in a dorsal direction; ventral interior with flabellate muscular area; dorsal interior with four bladelike plates arising from floor of valve between adductor scars. **M. Ord.** (Chazy) (N. Y., S. Appalachians).

D. geniculata U and C (**132**—14, 15). Posterior half gently convex; valves geniculated about half the length from beak; angle of geniculation 100°. **Chazy:** Lake Champlain area of N. Y.

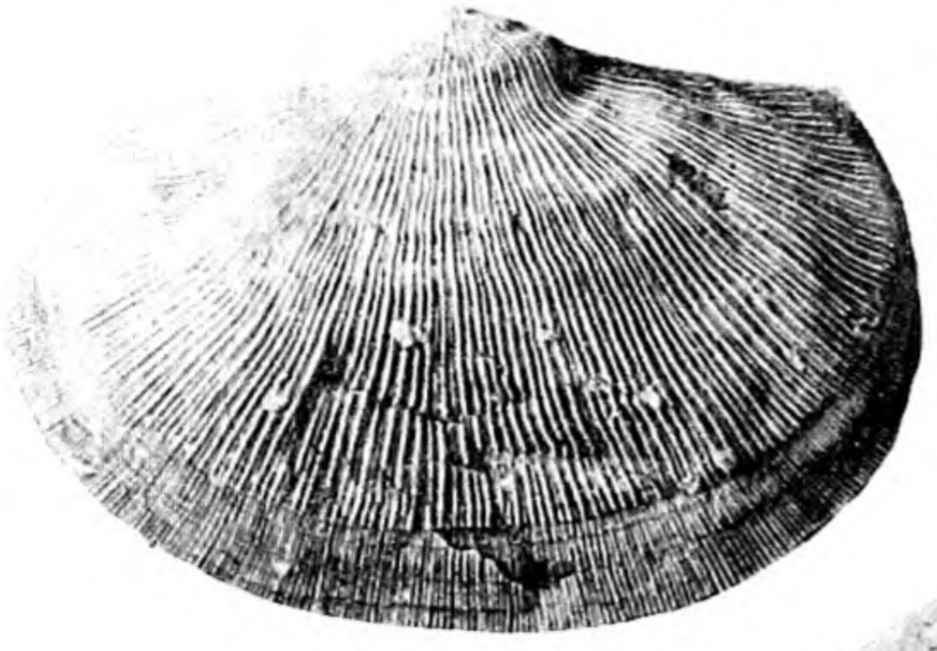
LEPTAENA Dalman 1828

(**Conchita rhomboidalis* Wilckens). Concavo-convex; valves strongly geniculated at front with posterior portion only slightly convex; costellate, valves often concentrically wrinkled; ventral valve with apical foramen, long palintrope; thickened margin to oval muscular area; dorsal valve with large bilobed cardinal process and thickened adductor field. **M. Ord.–Miss.** (widespread throughout N. America).

PLATE 133

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–8. Orthotetes spp. 1–4. O. keokuk. Post view; D and V exts; V view of int F. **5–8. O. kaskaskiensis** [Ill G S, M 1]. Post and S views; V and D exts. **9–16. Meekella striatocostata.** V ext and Post and S views of a small Permian specimen; S and Post views of a Pennsylvanian specimen; Post views (x1, x2) of D ints showing cardinal process; S view of a Pennsylvanian specimen showing long twisted beak. **17–21. Derbyia spp. 17–19. D. bennetti.** Post, D, and V views. **20, 21. D. crassa.** V and D exts.



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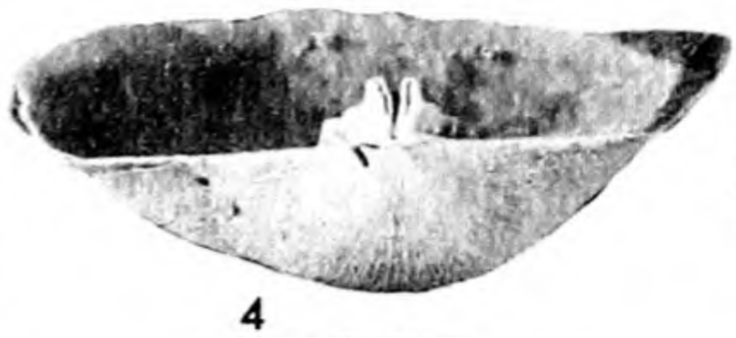

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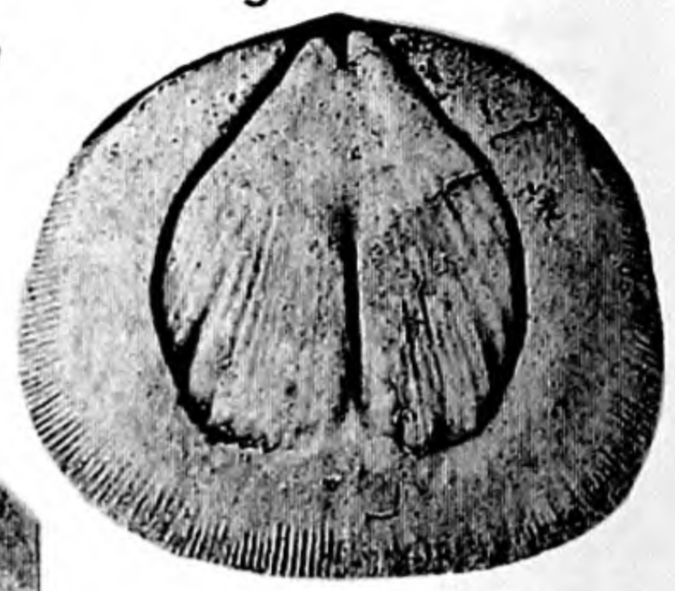

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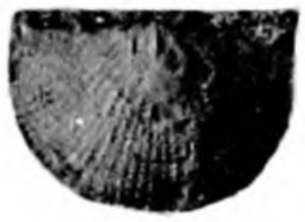

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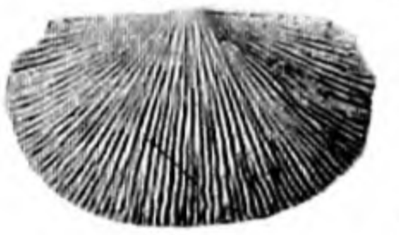

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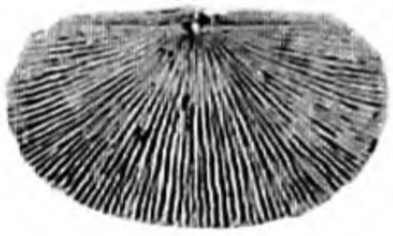

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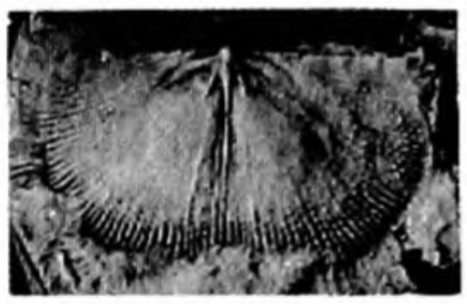

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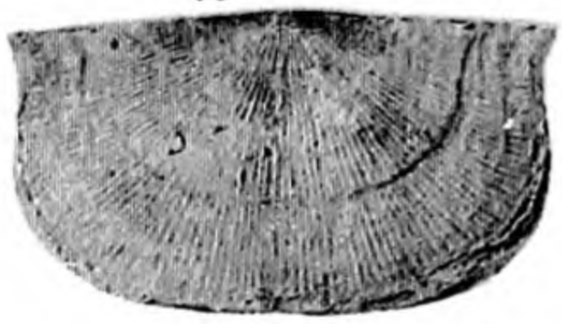

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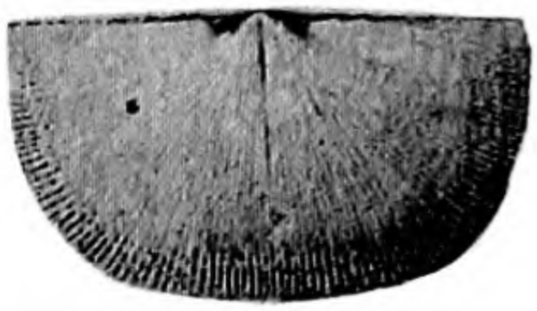

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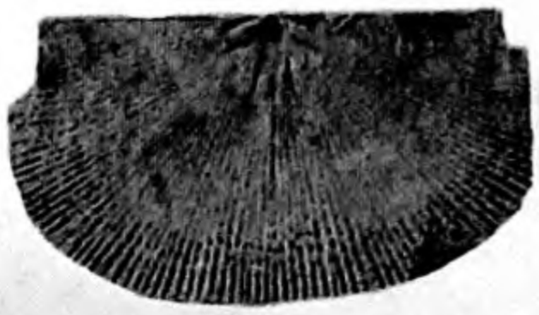

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***L. "rhomboidalis"** (**132**—16–22). A name applied to most wrinkled members of the genus throughout the **Sil** and **Dev.**; of little stratigraphic value.

L. richmondensis Foerste (**132**—23–25). Twice as wide as long; cardinal extremities alate; geniculated area short; costellae mostly of one size. **U. Ord.** (Richmond): Ohio Valley.

L. unicostata (Meek and Worthen) (**132**—26, 27). About 31 mm wide; cardinal extremities mucronate; geniculated area short; angle of geniculation about 90°; ventral valve marked by a single, strong, elevated median costella in a field of finer ones of two sizes. **U. Ord.:** U. Mississippi Valley (Maquoketa); Man.; Akpotok Is.

L. analoga (Phillips) (**132**—28, 29). Large, attaining a width of 43 mm; strongly geniculated with a short geniculated area; concentric wrinkles strong, occupying most of the valve; ventral muscular area small. **Miss.** (Chouteau–Burlington): Mississippi Valley, Utah, Nev.

HOLTEDAHLINA Foerste 1924

(**Leptaena sulcata* Verneuil). Biconvex, strong dorsal fold; otherwise like *Strophomena*. **M.** to **U. Ord.** (Trenton–Richmond) (Appalachians, Ohio Valley, W. Tenn., Mississippi Valley).

***H. sulcata** (Verneuil) (**132**— 30–33). **Richmond:** Ohio Valley.

LEPTAENISCA Beecher 1890

(**Leptaena concava* Hall). Concavo-convex; attached by ventral beak when young; costellate; ventral interior with elongate muscular field and with strong median adductor septum; dorsal interior with a more or less well defined spiral impression of one volution on each side of median line. **M. Sil.** to **Dev.** (Onondaga) (N. B., Que.; N. Y., Appalachians, Midwest, W. Tenn., Okla.).

***L. concava** (Hall) (**132**—34, 35). **Helderberg** (New Scotland): Same distribution as genus.

LILJEVALLIA Hedström 1917

(**L. gothlandica*). Small, planoconvex, smooth; attached by surface of ventral valve, which has elongate muscular area and prominent median septum. **M. Sil.** to **L. Dev.** (N. Y., W. Tenn., Okla.).

L. adnascens (Hall and Clarke) (**132**—41, 42). **Helderberg** (New Scotland): N. Y., W. Tenn., Okla.

FARDENIA Lamont 1936

(**F. scotica*). Biconvex, costellate; ventral valve with long palintrope, convex pseudodeltidium without apical foramen; ventral interior with flabellate muscular field and dental plates; dorsal valve with bilobed cardinal process and brachial processes fused by shell substance to form a tentlike structure. **M.** and **U. Sil.** (N. B., Que.; N. Y., Appalachians, Ind., Ky., W. Tenn., Mississippi Valley).

F. subplana (Conrad) (**132**—36–40). **M. Sil.:** Widespread throughout U. S. A.

SCHUCHERTELLA Girty 1904

(**Streptorhynchus lens* White). Irregular in shape, often attached by part of ventral valve, occasionally biconvex but usually with ventral valve concave or with less depth than dorsal; costellate; ventral valve without dental plates but with flabellate muscular area; dorsal valve with cardinal and brachial processes fused. **L. Dev.–Perm.** (all areas of outcrop).

S. woolworthana (Hall) (**132**—49–51). Large, strophomenoid in appearance, slightly wider than long; width up to 50 mm, length to 43 mm; ventral valve gently concave, dorsal moderately convex; ventral interarea short, not distorted. **L. Dev.** (New Scotland and equivalents): Que.; N. Y., Appalachians, W. Tenn., Mo., Okla.

S. perversa (Hall) (**132**—43–45). Small, wider than long, attaining 25 mm or slightly more in width; ventral valve flatly subpyramidal, usually somewhat distorted. **M. Dev.** (Hamilton): Ont.; N. Y., Appalachians, Ind.

S. desiderata Hall and Clarke (**132**—46–48). **Miss.** (Waverly): Ohio.—

***S. lens** (White). **Miss.:** Mo. (Kinderhook).

HIPPARIONYX Vanuxem 1842

(**H. proximus* Vanuxem (**134**—6, 7), with distribution of genus). Circular in outline, costellate; internally like *Schuchertella* but ventral interior with flabellate muscular field occupying nearly entire surface. **Dev.** (Oriskany) (Que.; N. Y., Appalachians, W. Tenn., Ill., Mo., Okla.).

ORTHOTETES Fischer 1850

(**O. radiata*). Shells often large, costellate, ventral valve irregular, dorsal valve convex; ventral interior with short spondylium surrounded by flabellate muscular area; dorsal interior as in *Schuchertella*. **Miss.–Perm.** (Appalachians, Midwest, Mississippi Valley, Midcontinent, Tex., Great Basin).

O. keokuk Hall (**133**—1–4). Very large, attaining a width of about 75 mm and a length of 62 mm; cardinal extremities rounded; ventral valve flat or slightly concave. **Miss.** (Keokuk): Appalachians, Ohio Valley, Mississippi Valley.

PLATE 134

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–5. Derbyia cymbula. V, D, and Post views of a complete specimen; Post view of cardinal process; V int. **6, 7. Hipparionyx proximus.** Post view of Imp D int showing forked cardinal process; Imp V int. **8–29. Chonetes** spp. **8, 9. C. novascoticus.** D ext; Imp V int (x2). **10. C. aurora.** V ext (x2). **11. C. scitulus.** D ext (x2). **12–15. C. coronatus.** V, D, and S views; D int. **16. C. macrostriatus** [GSA, SP 25]. D ext, slightly reduced. **17–20. C. oklahomensis.** D int (x2); D ext; D and V ints. **21–23. C. syrtalis.** D ext; Imp V and D ints. **24–26. C. granulifer.** D ext; V and D int. **27. C. jerseyensis.** V ext. **28, 29. C. shumardianus** [Ill G S, M 1]. V int and ext. **30, 31. Leptodus americanus.** D view, both valves in place; V int.

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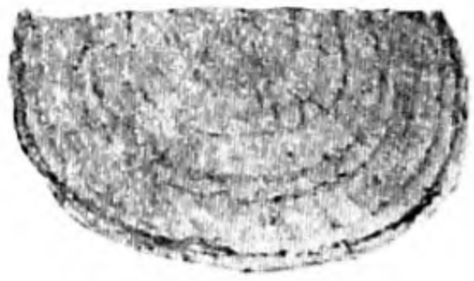
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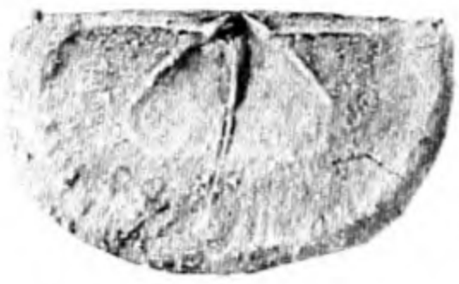
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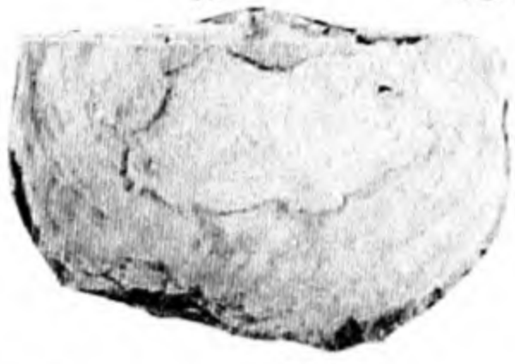
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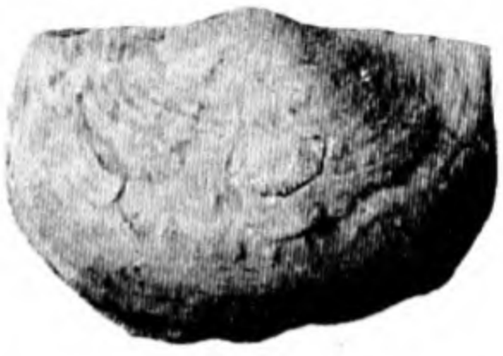
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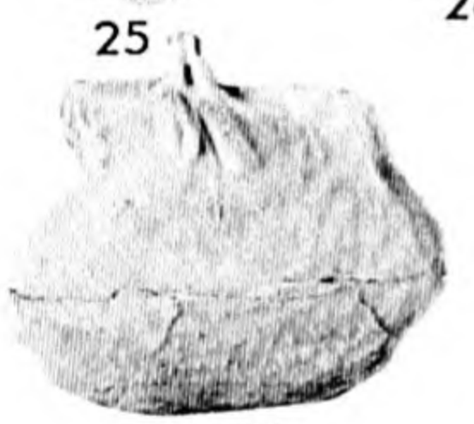
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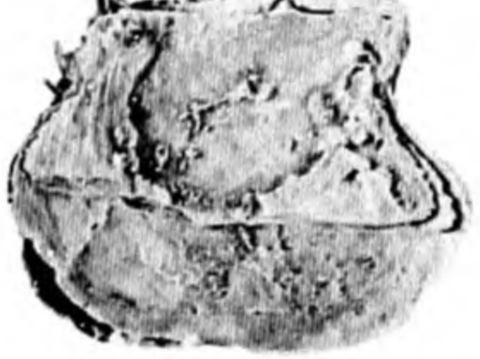
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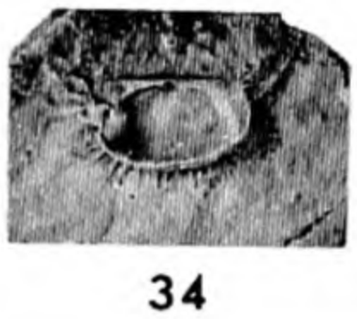
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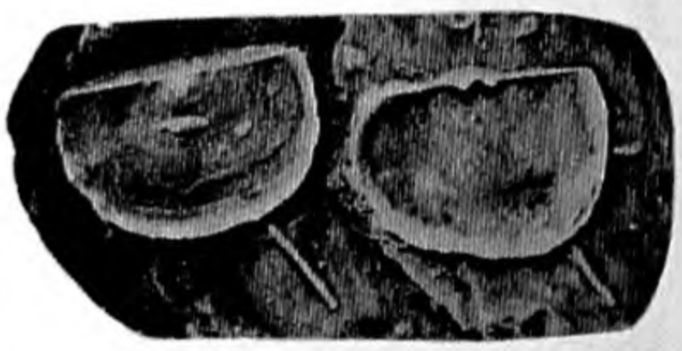
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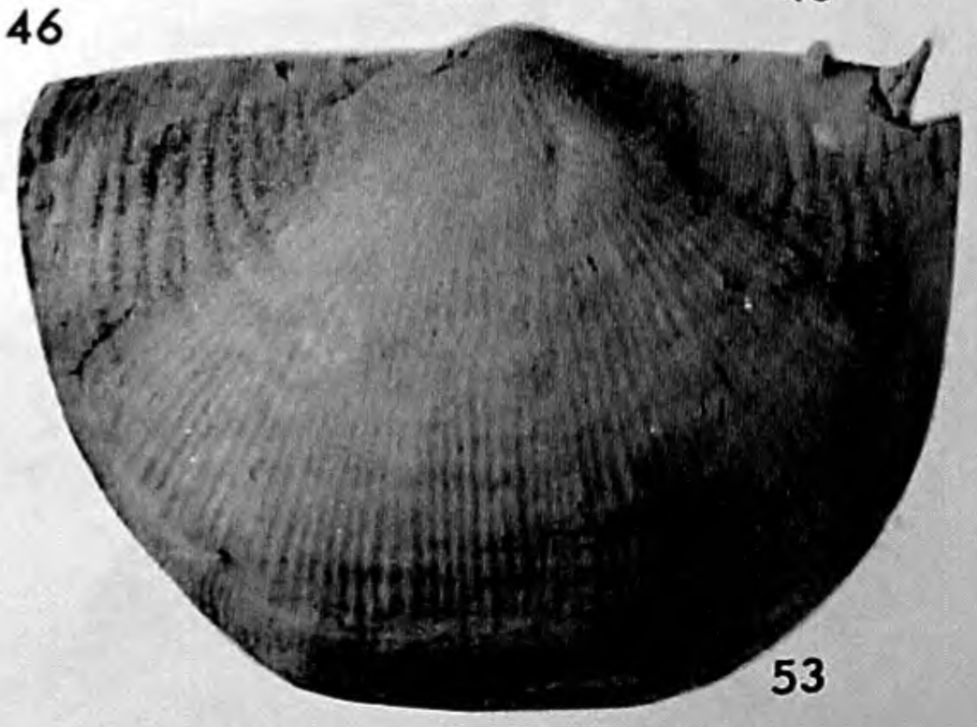
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O. kaskaskiensis McChesney (**133**—5–8). Smaller than preceding, with more deeply concave ventral valve. **Miss.** (Chester): S. Appalachians, Mississippi Valley.

DERBYIA Waagen 1884

(**D. regularis*). Shells with irregular ventral valve, often attached when young, convex dorsal valve; ventral interior without dental plates but with a strong median septum; dorsal valve with large forked cardinal process and widely divergent supporting plates; multicostellate. **Penn., Perm.** (S. Appalachians, Ohio, Ind., Ky., Mo., Midcontinent, Tex., Great Basin).

D. crassa (Meek and Hayden) (**133**—20, 21). Small for the genus; length and width, and depth of valves subequal; hinge narrower than greatest width; interarea short. **Penn.:** Ky., Ill., Mo., Neb., Kan., Okla.

D. bennetti Hall and Clarke (**133**—17–19). Small, valves very unequal in depth, ventral interarea long, often misshapen; ventral valve concave, dorsal valve ventricose. **U. Penn.:** Mo., Neb., Kan., Tex.

D. cymbula Hall and Clarke (**134**—1–5). Large, attaining a width of 75 mm and a length of more than 50 mm; outline transversely elliptical to subcircular; ventral valve gently concave; dorsal valve moderately convex; interarea moderately long, irregular in shape; cardinal process small. **U. Penn.–L. Perm.:** Neb., Kan., Tex.

MEEKELLA White and St. John 1867

(**Plicatula striatocostata* Cox). Large: ventral valve of irregular shape, generally with convex profile and often with twisted beak; dorsal valve convex; ventral interior with two thin high dental plates; dorsal interior with long forked cardinal process supported by two high divergent plates. **Penn., Perm.** (Ky., Midwest, Midcontinent, Tex., southwestern U. S. A. and Great Basin, Ore.).

***M. striatocostata** (Cox) (**133**—9–16). **Penn., Perm.:** Widespread throughout U. S. A.

LEPTODUS Kayser 1883

(**L. richthofeni*). Ostreiiform in appearance and growth habit, attached; ventral interior with narrow thickened hinge area; median septum dividing a series of lateral grooves and ridges; dorsal valve highly specialized consisting of narrow axial thickening and lateral branches that fit over the ventral grooves; rudimentary cardinal process. **Perm.** (Tex., N. Mex.; B. C.).

L. americanus (Girty) (**134**—30, 31). **Perm.:** W. Tex.

PRODUCTACEA. Aberrant shells usually with shallow body cavity and one or both valves provided with hinge or body spines serving as anchors, struts, or supports.

CHONETES Fischer 1837

(**C. variolata* Orbigny). Generally semielliptical to semicircular in outline, large or small, concavo-convex in profile; hinge straight; posterior margin of ventral valve provided with oblique, hollow spines; ventral interior with large flabellate muscle field and more or less well defined median septum; dorsal interior with erect quadrilobate cardinal process, low median septum. **M. Sil.–Perm.** (all areas of outcrop of these strata).

C. novascoticus Hall (**134**—8, 9). Width about 25 mm, semicircular to semielliptical in outline; gently concavo-convex; about seven spines on each side of beak. **M. Sil.:** N. S. (Arisaig); Me.

C. jerseyensis Weller (**134**—27). About 25 mm wide, slightly convex, with about 10 short spines on each side of beak; costae extending obliquely from posterior margin. **Sil.** (Keyser): N. Y., Appalachians.

C. macrostriatus Walcott (**134**—16). Suggesting *C. jerseyensis* in ornamentation but much more convex. **L. Dev.:** Nev. (L. Nevada).

C. syrtalis (Conrad) (**134**—21–23). Large, as much as 45 mm wide and 25 mm long; dorsal valve gently concave to flat; ventral muscular area occupying most of inner surface. **M. Dev.** (Marcellus–Skaneateles): N. Y., Pa., Mich., Ill.

C. coronatus (Conrad) (**134**—12–15). **M. Dev.** (Hamilton): Widespread.

C. scitulus Hall (**134**—11). Small, about 12 mm wide and 6 mm long; sides rounded to subalate; five or six spines on each side of beak. **M. Dev.** (Hamilton): Ont.; N. Y., Appalachians, Ohio, Ind.

C. aurora Hall (**134**—10). Small, resembling *C. scitulus* in size but ornamented by strong concentric lines which cancellate the costellae. **M. Dev.** (L. Tully): N. Y., Pa.

C. shumardianus Koninck (**134**—28, 29). About 19 mm wide, 13 mm long; moderately convex; three to five spines on each side of beak. **Miss.** (Keokuk): Ind., Ky.

C. oklahomensis Snider (**134**—17–20). Resembling the preceding but slightly smaller, with rec-

PLATE 135

[All figures are x1 and original by Cooper unless otherwise indicated.]

1, 2. Longispina emmetensis. V and D exts. **3–5. Eodevonaria arcuata.** D int; two views of Imp V int. **6–8. Mesolobus mesolobus** (x2). D and V exts; D int. **9, 10. Chonostrophia complanata.** V ext and int. **11, 12. Chonetina flemingi** (x2). V and D exts. **13, 14. Lissochonetes geinitzianus.** V ext; D ext (x2). **15, 16. Chonopectus fisheri.** Imp V ext; V ext. **17–20. Anoplia nucleata.** V and D exts; V and D ints. **21–30. Productella** spp. **21–23. P. truncata** [Pal N Y 4]. Post, V, and S views. **24–26. P. walcotti.** V and D exts; D int (x2). **27, 28. P. hirsutiformis.** D and V exts. **29, 30. P. spinulicosta.** S and V views [Pal N Y 8 (1)]. **31–33. Aulosteges** sp. D int; V and D exts. **34, 35. Leptalosia radicans.** V int; D int (x4). **36, 37. Heteralosia slocomi.** V and D exts. **38–40. Strophalosiina magnicostata.** V and D exts; D int (x2). **41. Leptalosia scintilla** (x8) [JP 12]. D ext and V int. **42–45. Diaphragmus cestriensis.** D and S views. V and S views [Ill G S, M 1]. **46–48. Avonia oklahomensis.** V, Ant, and S views. **49–51. Marginicinctus marginicinctus.** D and V exts [Ill G S, M 1]; Imp D ext showing flange. **52, 53. Marginirugus magnus.** D int; V ext.

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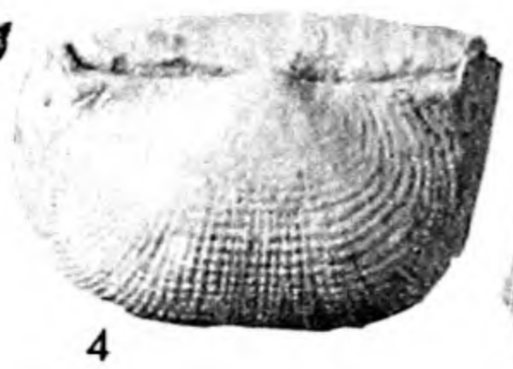
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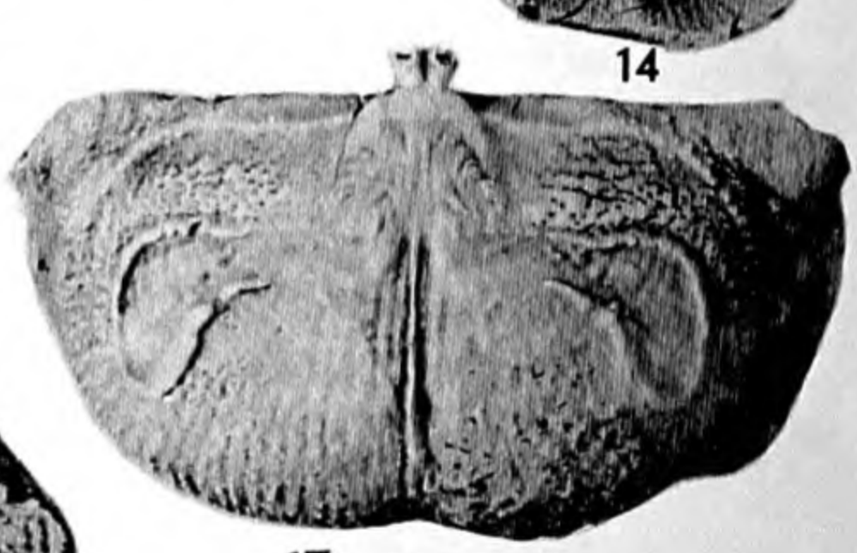
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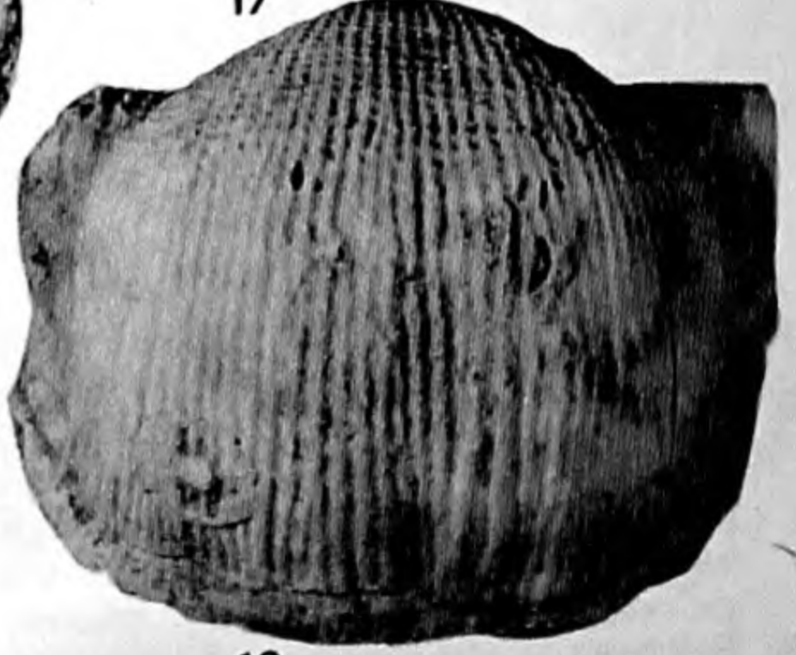
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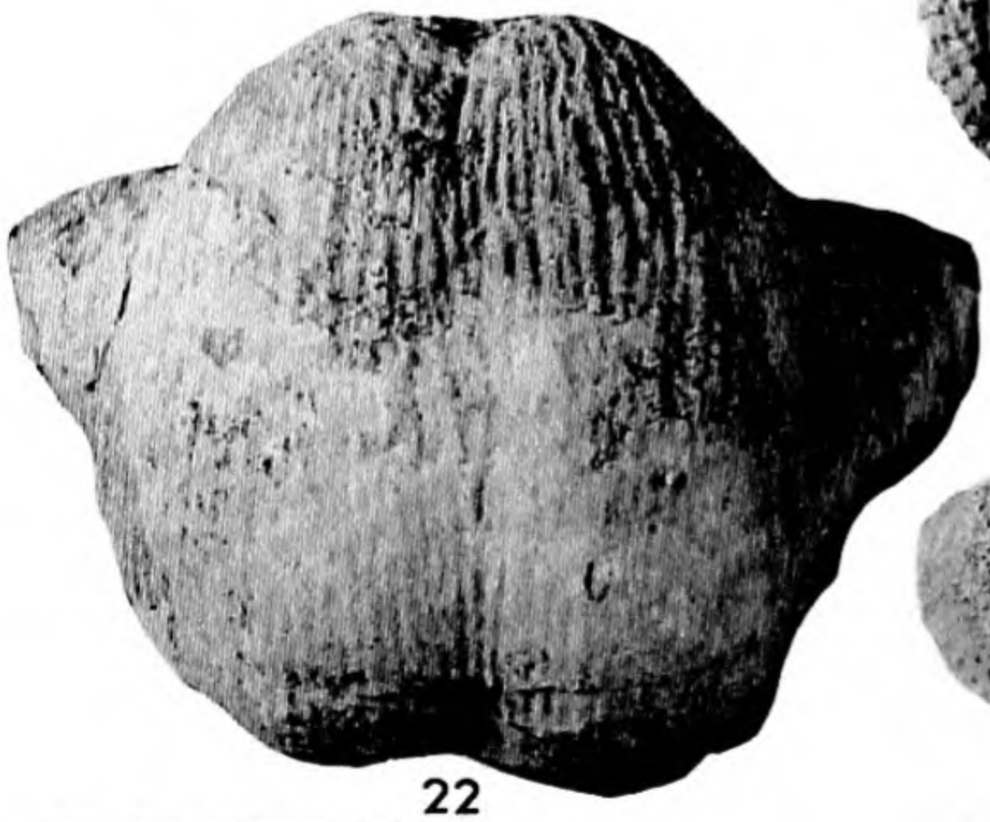
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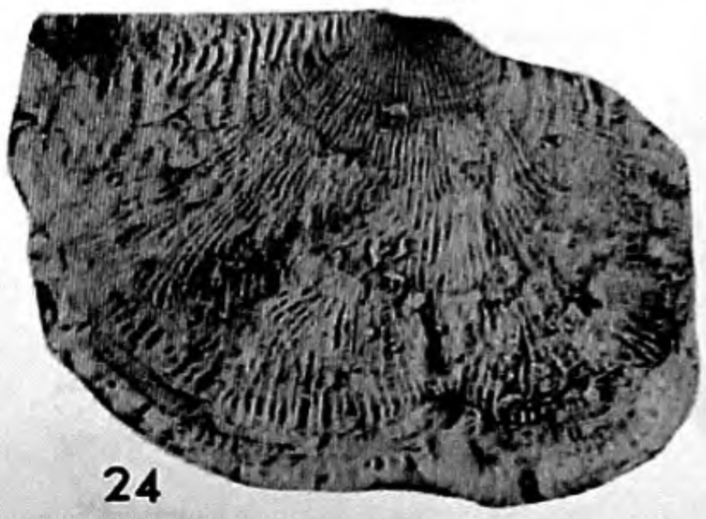
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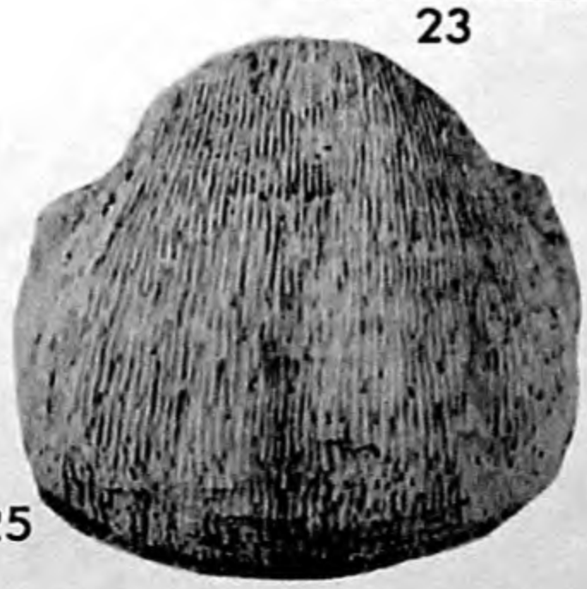
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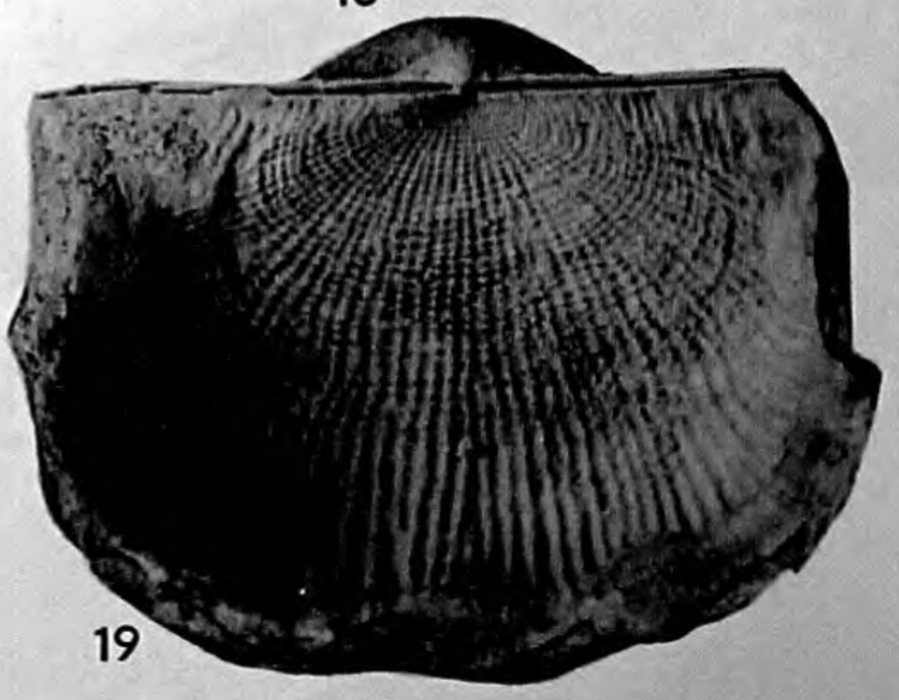
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tangular cardinal extremities and eight or nine small spines on each side of beak. **Miss.** (Fayetteville): Okla.

C. granulifer Owen (**134**—24–26). Subsemicircular, hinge wide, cardinal extremities alate; attaining a width of 25 mm along hinge, length about half the hinge width; costellae very fine and even; 10 spines on each side of beak. **Penn.:** S. Appalachians, Ohio, Ind., Ky., Midcontinent, Tex., southwestern U. S. A.

LONGISPINA Cooper 1942

(**Chonetes emmetensis* Winchell). Small, subquadrate, strongly concavo-convex; costate; posterior margin of ventral valve with long spines subparallel to hinge; interior like *Chonetes coronatus*. **L. to M. Dev.** (Onondaga–Tully) (Que., Ont.; N. Y., Appalachians, W. Tenn., Mississippi Valley).

***L. emmetensis** (Winchell) (**135**—1, 2). **Traverse:** Mich.

EODEVONARIA Breger 1906

(**Chonetes arcuatus* Hall). Generally strongly convex chonetids with denticulate hinge and interior like Devonian *Chonetes*. **L.** and **M. Dev.** (Oriskany–Onondaga) (Que., Ont.; N. Y., Appalachians, Ind., W. Tenn., Ill., Okla.).

***E. arcuata** (Hall) (**135**—3–5). **Onondaga:** Same distribution as genus.

CHONOSTROPHIA Hall and Clarke 1892

(**Chonetes reversa* Whitfield). Like *Chonetes* internally but with ventral valve concave and dorsal valve convex. **M. Sil. to M. Dev.** (Marcellus) (Que., Ont.; N. Y., Appalachians, W. Tenn., Ill., Okla.).

C. complanata (Hall) (**135**—9, 10). Fairly large, length two-thirds the width; very finely costellate; three spines on each side of beak. **L. Dev.** (Oriskany): Que., Ont.; N. Y., Appalachians.

MESOLOBUS Dunbar and Condra 1932

(**Chonetes mesolobus* Norwood and Pratten). Like *Chonetes* internally; costellate; ventral valve with broad median sulcus occupied by a narrow fold and on the dorsal valve a low fold bearing a sulcus. **L. Penn.** (W. Va., Ohio, Ind., Midcontinent, Tex., N. Mex.).

***M. mesolobus** (N and P) (**135**—6–8). **L. Penn.:** Widespread throughout U. S. A.

LISSOCHONETES Dunbar and Condra 1932

(**Chonetes geinitzianus* Waagen). Concavo-convex, smooth exterior; interior like *Chonetes* but with dorsal septum nearly obsolete; ventral valve with broad median sulcus and dorsal valve with corresponding fold. **Penn., Perm.** (Midcontinent, Tex.).

***L. geinitzianus** (Waagen) (**135**—13, 14). **Penn.:** Widespread throughout U. S. A.

CHONETINA Krotow 1888

(**Chonetella artiensis*). Ventral valve strongly convex and provided with a deep, narrow sulcus; dorsal valve with median fold; exterior costellate. **Penn.** (Midwest, Midcontinent, southwestern U. S. A.).

C. flemingi (Norwood and Pratten) (**135**—11, 12). **Penn.:** Widespread in U. S. A.

CHONOPECTUS Hall and Clarke 1892

(**Chonetes fischeri* Norwood and Pratten). Concavo-convex, wider than long; interarea short, posterior margin provided with spines, the longer ones on the outside; exterior marked by fine radiating lines crossed by oblique concentric lines forming a quincuncial pattern. **U. Dev.** to **L. Miss.** (N. Y., Mississippi Valley.)

***C. fischeri** (N and P) (**135**—15, 16). **L. Miss.:** Ia. (Kinderhook).

ANOPLIA Hall and Clarke 1892

(**Leptaena? nucleata* Hall). Small, strongly concavo-convex; surface smooth; posterior margin without spines; interior like *Chonetes*. **Dev.** (Oriskany–Onondaga) (Que., Ont.; N. Y., Appalachians, W. Tenn., Ill., Okla.).

***A. nucleata** (Hall) (**135**—17–20). Range and distribution same as genus.

PRODUCTELLA Hall 1867

(**Productus subaculeatus* Murchison). Concavo-convex, ventral valve provided with long spines, teeth on each side of delthyrium, and a short interarea; dorsal valve with erect lobate cardinal process, usually without spines. **Dev., Miss.** (Onondaga–St. Louis) (Ont.; Canadian Rockies; Mackenzie basin; N. Y., Appalachians, Midwest, Rocky Mts. and Great Basin).

P. truncata Hall (**135**—21–23). Very small, ventral umbo broadly truncate; dorsal valve moderately concave; valves wrinkled at hinge and covered by more or less scattered elongate pustules bearing spines. **L.** to **U. Dev.** (Onondaga–Naples): Que.; N. Y., Appalachians.

P. spinulicosta Hall (**135**—29, 30). Semielliptical in outline with surface marked by strong concentric lines and several rows of interrupted spine bases; ears strongly wrinkled with four or five spines. **Hamilton:** N. Y., Appalachians, Mich., Ohio, Ind.

P. lachrymosa (Conrad). Semielliptical in outline,

PLATE 136

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–19. Dictyoclostus spp. 1–3. D. burlingtonensis [Ill G S, M 1]. Post, V, and S views. **4–6. D. ferntglenensis** [Ill G S, M 1]. Post, S and V views. **7, 8. D. portlockianus.** S and V views. **9–14. D. inflatus.** D, V, Post, and S views; D and V ints. **15–19. D. americanus.** S and Post views; D int; V and D exts. **20. Buxtonia semicircularis.** D ext. **21. Buxtonia peruviana.** D view. **22. Dictyoclostus bassi.** V ext. **23–25. Setigerites setigerus.** D int; D ext showing anterior flange; Imp V int.

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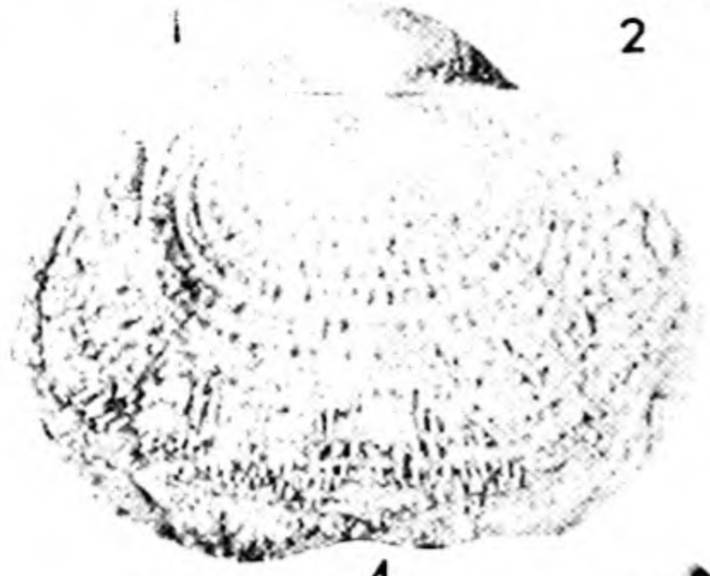
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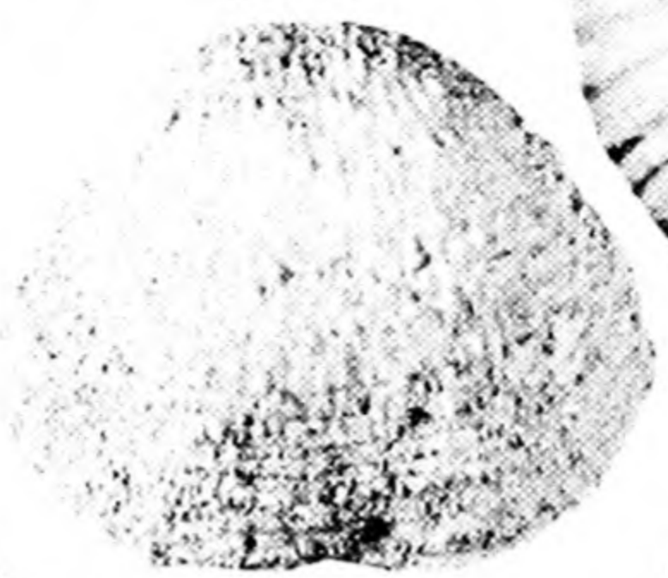
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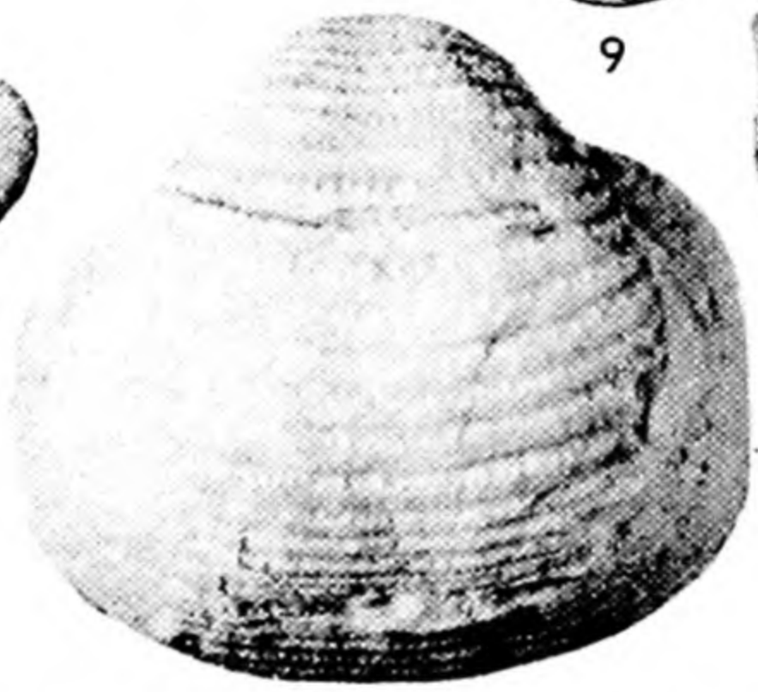
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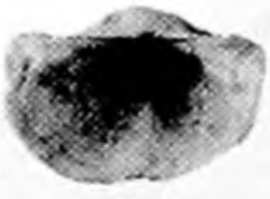
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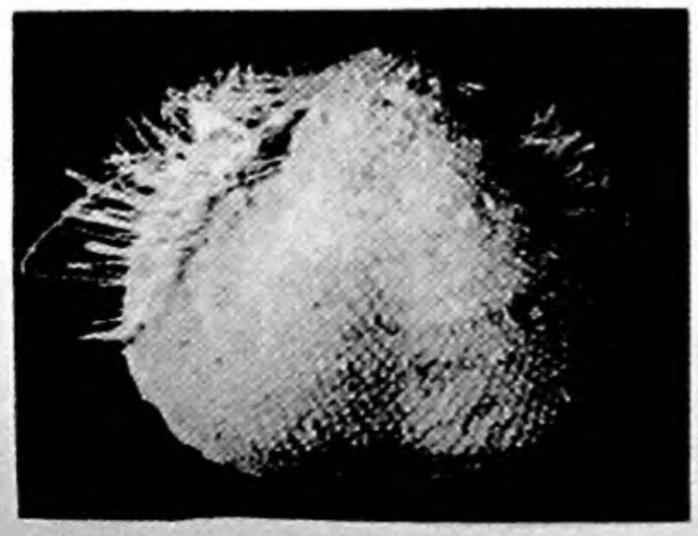
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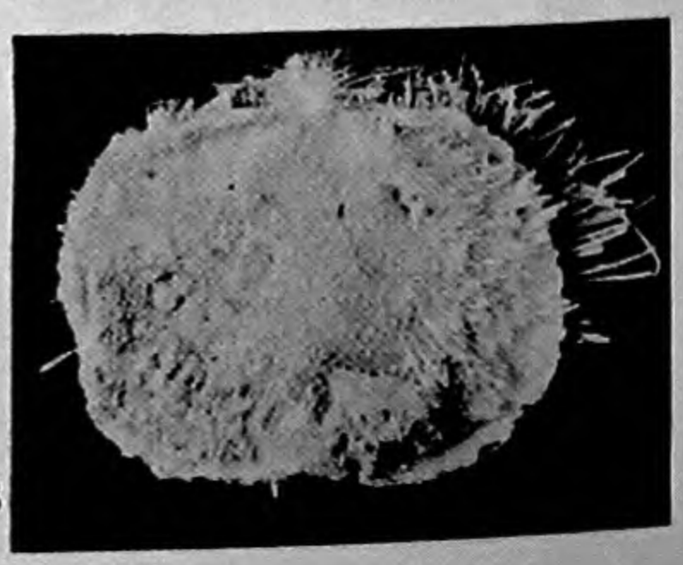
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ventral valve strongly convex; umbo often elevated and incurved; ears strongly wrinkled, with four or five spines; spiniferous tubercles arranged in lines along partly continuous ridges. **Chemung:** N. Y., Appalachians.

P. walcotti Fenton and Fenton (**135**—24–26). Slightly longer than wide; ventral valve with scattered spines and fine costellae; dorsal valve with regular concentric lamellae (now *Devonoproductus* of Stainbrook). **U. Dev.:** Ia. (Hackberry).

P. hirsutiformis Walcott (**135**—27, 28). Very large for the genus; thin-shelled; semielliptical in outline with wide hinge; convexity low, not strongly umbonate; surface concentrically wrinkled, with fairly numerous small scattered spines. **Miss.** (Moorefield): Ark., Okla., Nev.

LEPTALOSIA Dunbar and Condra 1932

(**Strophalosia scintilla* Beecher). Small, attached by ventral surface and by spines from hinge and anterior; ventral interior with hinge-teeth; dorsal valve smooth with large bilobed cardinal process. **Dev.–Penn.** (Ont.; Mich., Ia., Mo., Neb., Kan., Tex.).

L. radicans Winchell (**135**—34, 35). Fairly large, attaining a width of 6 mm; semielliptical to subrectangular in outline; attaching spines moderately long; cardinal process large. **M. Dev.:** Mich. (Traverse). (A related rare species in Hamilton of Ont.)

***L. scintilla** (Beecher) (**135**—41). Suggesting preceding, but minute. **Miss.** (Louisiana): Mississippi Valley.

AULOSTEGES Helmersen 1847 (**135**—31–33)

(**A. variabilis*). Small to large; concavo-convex; surface spinose with long hinge-spines; ventral apex usually deformed; interarea long with prominent narrow pseudodeltidium; cardinal process large, erect. **Perm.** (Tex., Wyo., Idaho).

A. wolfcampensis King from **Wolfcamp** and **A. "medlicottianus"** Waagen from **Leonard.**

STROPHALOSIINA Licharew 1935

(**Aulosteges tibeticus* Diener). Small, plano-convex, anteriorly geniculate, costate, with long ventral interarea; attached by ventral beak and further anchored by long spines arranged around periphery of ventral valve and pointing posteriorly; body of ventral valve with long slender spines directed anteriorly; dorsal valve with long cardinal process at right angles to valve surface; dorsal periphery with single row of short spines. **Perm.** (Tex. [Leonard from Glass Mts.]).

S. magnicostata (Girty) (**135**—38–40). Range and distribution same as genus.

HETERALOSIA King 1938

(**H. slocomi*). Concavo-convex; ventral valve with cicatrix of attachment and short oblique spines; dorsal valve without spines. **Dev.–Perm.** (N. Y., Appalachians, Mississippi Valley, Tex.

***H. slocomi** King (**135**—36, 37) **Penn :** Tex.

DIAPHRAGMUS Girty 1910

(**Productus elegans* Norwood and Pratten). Generally small, fairly evenly costate, umbonal region reticulate, spines erect, confined to ventral valve; trail moderately long; dorsal valve provided with flangelike diaphragm. (May equal *Productus ss* of British and Belgian Carboniferous.) **Miss.** (Ste. Genevieve–Chester) (Appalachians, Midwest, Tenn., Wyo., Ariz., Great Basin; Sonora, Mexico).

D. cestriensis (Worthen) (**135**—42–45). **Miss.** (Chester): S. Appalachians, Ky., Mississippi Valley, Ark., Okla.

AVONIA Thomas 1914 (**105**—4)

(**Productus youngianus* Davidson). Small to medium in size; convex ventral valve with scattered long and erect spines, often anteriorly costate; dorsal without spines. **Miss.** through **Perm.** (all areas of outcrop).

A. oklahomensis Snider (**135**—46–48). Large for the genus; length and width about equal (25 mm); ventral valve ventricose with flattened umbo, beak overhanging dorsal valve, trail long; dorsal valve nearly flat but with anterior geniculation at about right angle; posterior ornamented by rows of interrupted spiniferous granules that become strong continuous costae at place of geniculation and on trail. **Miss.:** Okla. Mayes .

MARGINICINCTUS Sutton 1938

(**Productus marginicinctus* Prout). Externally like a small *Dictyoclostus* but anterior margin with conspicuous convex ringlike border. **Miss., Penn.** (Mississippi Valley).

***M. maginicinctus** (Prout) (**135**—49–51). **Miss.** (St. Louis): Mo., Okla.

DICTYOCLOSTUS Muir-Wood 1930

(**Anomites semireticulatus* Martin). Generally large, with reticulate umbonal region and costate trail

PLATE 137

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–5. Juresania spp. 1–3. J. nebrascensis. D ext; D int; S view. **4, 5. J. symmetrica.** D and V exts. **6–15. Echinoconchus spp. 6–9. E. biseriatus** [Ill G S, M 1]. V, D, and S views; D int. **10–12. E. alternatus** [Ill G S, M 1]. S and D views; D int. **13–15. E. semipunctatus.** D, V, and S views. **16–28. Marginifera spp. 16–18. M. lasallensis.** V and D exts; V int showing elevated margin. **19. M. splendens.** D ext. **20–23. M.? adairensis.** V and D exts; D and V ints. **24–26. M.? muricatina.** D and V exts; D int (x2). **27, 28. M. wabashensis.** V and D exts. **29, 30. Teguliferina sp.** S view showing spines; D ext. **31. Linoproductus prattenianus.** D ext. **32–34. Linoproductus ovatus** [Ill G S, M 1]. Post, V, and S views. **35–38. Waagenoconcha montpelierensis.** D and V exts showing spine bases [USGS, B 436]; V and D exts (x2) preserving many spines.

having few erect spines; dorsal valve geniculate, without spines and without diaphragm. **Miss.–Perm.** (all areas of outcrop).

D. burlingtonensis (Hall) (**136**—1–3). About 31 mm long; width same; cardinal extremities slightly auriculate; ventral valve strongly convex and with a fairly deep sulcus; visceral cavity deep. **Miss.** (Burlington): Appalachians, Mississippi Valley.

D. fernglenensis Weller (**136**—4–6). **Kinderhook:** Mississippi Valley (Fern Glen).

D. inflatus (McChesney) (**136**—9–14). Resembling *D. burlingtonensis* but slightly smaller and with deeper and narrower ventral sulcus, inflated auriculate cardinal extremities and less prominent semireticulate markings in umbonal region. **Miss.** (Chester): Ill., Ala., Ark., Mo., Okla.

D. americanus Dunbar and Condra (**136**—15–19). Large, subrectangular in outline, about 63 mm wide and 31 mm long; surface strongly semireticulate; cardinal extremities only slightly auriculate; ventral valve moderately convex, umbo not inflated. **Penn.** (Missouri): Mo., Neb., Kan., Tex.

D. portlockianus (Norwood and Pratten) (**136**—7, 8). Of medium size, attaining a length and width of 38 mm; ventral valve strongly convex with maximum convexity at middle; umbo not inflated, strongly semireticulate; sulcus, if present, narrow, shallow and originating at middle. **Penn.** (Cherokee–Lansing): Ind., Neb., Kan.

D. bassi McKee (**136**—22). Large, thick-shelled, attaining a length and width of 63 to 75 mm, ventral valve strongly convex, with arched umbo; cardinal extremities auriculate; ears arched; ventral sulcus not prominent. **Perm.:** W. Tex., Ariz.

MARGINIRUGUS Sutton 1938

(**Productus magnus* Meek and Worthen). Large, subhemispherical, concavo-convex; exterior marked by slender costae and obscure concentric rugae; anterior of ventral valve with shallow sulcus, low fold on front half of dorsal valve; ventral valve with scattered spines, dorsal valve with none; prominent thickened ridge on dorsal valve where it comes in contact with ventral valve. **Miss.** (Keokuk) (Ind., Ill., Mo., Okla.).

***M. magnus** (M and W) (**135**—52, 53). **Miss.** (Keokuk): Ind., Ill., Mo., Okla.

SETIGERITES Girty 1939

(**Productus setigerus* Hall). Resembling *Dictyoclostus* but with ventrally upturned anterior and lateral border. **Miss.** (Keokuk) (Ill., Ia., Okla.).

***S. setigerus** (Hall) (**136**—23–25). **Miss.** (Keokuk): Ill., Ia., Okla.

BUXTONIA Thomas 1914

(**Anomites scabriculus* Martin). Shells generally of large size, with oblique spines on both valves; posterior more or less reticulate; costae interrupted and with elongate spine bases. **Miss.–Perm.** (Appalachians, Ohio, Ind., Ky., Ark., W. Tex., Great Basin).

B. semicircularis Sutton and Wagner (**136**—20). Subtriangular, broadly oval in outline; umbo swollen; ventral sulcus deep and fairly wide. **Miss.** (Chester): Ky., Okla.

B. peruviana (Orbigny) (**136**—21). Subtrapezoidal to oval in outline; hinge very narrow, anterior broadly rounded; ventral moderately convex; dorsal valve nearly flat; beak greatly incurved over hinge; ventral median region broadly sulcate; dorsal valve with low median fold. **Perm.:** W. Tex. (Hueco).

JURESANIA Fredericks 1928

(**Productus juresanensis* Tschernyschew). Moderately large, attached when young; with small oblique or erect spines on both valves; early stages with fine spines, later stages with concentric bands carrying two sizes of spines, the smaller ones lying close to the shell, the larger ones at a high angle. **Penn., Perm.** (Midcontinent, Tex., Great Basin).

J. nebrascensis (Owen) (**137**—1–3). Small to medium in size, subquadrangular, length and width about equal; ventral valve strongly convex; umbo prominent; sulcus shallow; cardinal extremities slightly obtuse; dorsal valve gently concave; ventral cicatrix small. **Penn., Perm.:** Ind., Ky.

J. symmetrica (McChesney) (**137**—4, 5). Large, subcircular in outline; hinge less than greatest width; ventral valve nearly hemispherical, without median sulcus; dorsal valve gently concave; spines generally smaller and more numerous than in preceding. **Penn.:** Ia., Mo., Neb., Kan., Tex.

ECHINOCONCHUS Weller 1914

(**Anomites punctatus* Martin). Generally elongate shells with subparallel sides and strongly incurved ventral beak; spines on both valves, strong concentric bands containing spines of several sizes; dorsal valve concave but not geniculate. **Miss.–Perm.** (S. Appalachians, Ind., Ky., Tenn., Mississippi Valley, Midcontinent, Tex., Great Basin).

E. biseriatus (Hall) (**137**—6–9). Shell small, length and width about equal, ventral valve without a sulcus; dorsal valve without a fold. **Miss.** (Warsaw): Ind., Okla.

E. alternatus (Norwood and Pratten) (**137**—10–12). Of medium size for genus; length and width subequal, about 50 mm; ventral valve moderately and evenly convex; dorsal valve moderately concave; concentric bands distant on ventral valve, more crowded on dorsal; differs from *E. semipunctatus* in smaller size, less convexity, and less narrowed ventral posterior. **Miss.:** Mississippi Valley.

E. semipunctatus (Shepard) (**137**—13–15). Very large, attaining a length of 88 mm and a width of 75 mm; ventral valves with strong, narrow and convex profile; beak strongly incurved; sulcus shallow; lateral slopes nearly vertical in posterior part; dorsal valve concave to nearly flat; spines 3 to 4 mm in length. **Penn.:** Ind., Ill., Mo., Kan., Tex.

WAAGENOCONCHA Chao 1927

(**Productus humboldti* Orbigny). Concavo-convex shells covered by a mat of small oblique spines arranged in quincunx. **Perm.** (Tex., southwestern U. S. A., Wyo., Idaho).

W. montpelierensis Girty (**137**—35–38). **Perm.:** Wyo., Idaho, ?Tex.

MARGINIFERA Waagen 1884

(**M. typica*). Small, with strongly convex ventral valve; deeply concave dorsal valve with inner marginal ridge strongly developed. **Miss.** through **Perm.** (W. Va., S. Appalachians, Ohio, Ind., Ill., Mo., Ark., Neb., Kan., Tex., Great Basin).

M.? adairensis Drake (**137**—20–23). Length and width about equal (19 mm); hinge about equal to width; cardinal extremities slightly obtuse; ventral valve strongly convex and umbonate; dorsal valve deeply concave; finely costellate; spines few. **Miss.** (Fayetteville): Ark., Okla.

M. lasallensis (Worthen) (**137**—16–18). Moderately large, approaching 25 mm in length and width; strongly convex and with a long trail; posterior half with strong concentric lamellae; costellae seven to eight in 5 mm; spines few. **U. Penn.:** Ill., Ia., Mo., Kan., Okla., Tex.

M.? muricatina Dunbar and Condra (**137**—24–26). Subrectangular in outline; length about two-thirds the width; hinge nearly as wide as width at middle; cardinal extremities slightly obtuse; moderately concavo-convex; costae strong and of nearly uniform size; spines fine and numerous; dorsal interior with anterior covered by strong spines. **Penn.** (Des Moines): Ind., Ill., Ala., Ia., Mo., Kan., Okla., Tex.

M. splendens (Norwood and Pratten) (**137**—19). Transversely subrectangular in outline; auriculate; hinge generally forming widest part of shell; ventral sulcus deep; profile strongly concavo-convex; umbo flattened; trail long; radial ornament obscure; anterior with lamellose band; ears with one or two pairs of stout spines. **Penn.** (Des Moines–Kansas City): Ill., Ia., Mo., Neb., Kan., Okla., Tex.

M. wabashensis (Norwood and Pratten) (**137**—27, 28). Suggesting *M. splendens* but with strong costellae, narrower sulcus, and less extended cardinal extremities, but lacking the lamellose marginal border; ears without spines **Penn.** (Kansas City–Wabaunsee): Ind., Ill., Neb., Kan., Tex.

LINOPRODUCTUS Chao 1927

(**Productus cora* Orbigny). Small or large, generally costellate with small visceral area and long trail; umbonal slopes and ears often concentrically wrinkled; deep visceral chamber. **Miss.** through **Perm.** (all areas of outcrop).

L. ovatus (Hall) (**137**—32–34). Small, variable, longer than wide; ventral valve strongly convex in umbonal region, front half slightly convex in profile; dorsal valve deeply concave; hinge narrow; cardinal extremities and lateral slopes transversely wrinkled; spines slender, few and scattered. **Miss.** (Burlington–Chester): Ky., Mississippi Valley, Ark., Okla.

L. prattenianus (Norwood and Pratten) (**137**—31). Medium size; subhemispherical; hinge about equal to greatest width; length and width subequal; dorsal valve moderately concave; cardinal alae wrinkled; ventral hinge area with about 20 spines increasing in size away from beak; body of shell with erect scattered spines showing a quincuncial arrangement in oblique rows; spines 5 to 10 mm apart. **Penn.:** Ill., Mo., Neb., Kan., Tex.

L. oklahomae Dunbar and Condra (**138**—1, 2). **Penn.** (Lansing): Okla. (Stanton).

INSTITELLA Cooper 1942

(**Productus leonardensis* King [**138**—3–5]). Subrectangular in outline; ventral valve with deep narrow sulcus and long acute anterior tongue; interarea well developed; dorsal valve concave and with carinate fold on anterior two-thirds; sides of both valves reflected ventrally and with wide dorsally directed lateral frill; surface costellate, costellae reticulated by fine rugae on body. **Perm.** (W. Tex.).

TEGULIFERINA
Schuchert and LeVene 1929

(**Tegulifera deformis* Schellwien). Small, shallow, oblique, cup-shaped ventral valve attached by ventral apex and by spines; dorsal valve operculiform, flat with erect bilobed cardinal process. **Penn.** to **L. Perm.** (Ill., Mo., Neb., Kan., Tex.).

T. armata Girty (**137**—29, 30). **Penn.:** Mo. (in several formations), Neb. (Stoner), Kan. (Ft. Scott, Plattsmouth).

PRORICHTHOFENIA King 1930

(**Crania permiana* Shumard). Ventral valve conical; dorsal valve small, flat, located deep inside cone; open part of cone partly covered with long spines; ventral interior with long deep groove on posterior side; ventral side with high median septum; dorsal valve with bilobed cardinal process and spiny anterior; shell attached by apex and anchored by numerous long spines. **Perm.** (Tex.; Mex.).

P. uddeni (Böse) (**138**—43–45). Differs from type (from Word formation), which is long and slender, in its short and wide conical form and flaring chamber. **Perm.** (Leonard): W. Tex.

Punctate Articulata. Shells punctate.

DALMANELLACEA. Subcircular to elliptical, plano- to biconvex shells having brachiophores and generally a small lobate cardinal process.

RESSERELLA Bancroft 1928

(**Orthis canalis* Sowerby). Generally circular to semielliptical, costellate; deeply convex ventral valve, gently convex dorsal valve; ventral interior with elongate diductor scars; dorsal valve with trilobed cardinal process and flat oblique brachial

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processes supported by callus. **M. Ord.** to **L. Sil.** (widespread throughout N. America).

R. rogata (Sardeson) (**138**—6, 7). Small, circular in outline, ventral fold not pronounced, costellae somewhat fasciculated; ventral muscular field long and narrow. **L.** and **M. Trenton:** N. Y., Appalachians, Mississippi Valley.

R. fertilis Bassler (**138**—10). Fairly large, planoconvex: ventral valve subcarinate; dorsal sulcus narrow and shallow; costellae fine. **M. Ord.** (Trenton): Appalachians, Ky., Tenn.

R. multisecta (Meek) (**138**—15–18.) Transversely subelliptical to subcircular in outline; ventral valve subcarinate posteriorly but broadly convex anteriorly; sulcus narrow and deep posteriorly, broad anteriorly. **U. Ord.** (Eden): N. Y., Appalachians, Ohio Valley, W. Tenn.

R. (Onniella) meeki (Miller) (**138**—11–14). Subrectangular in outline; cardinal extremities narrowly rounded; ventral valve strongly carinate; dorsal valve deeply sulcate. **U. Ord.** (Richmond): Ohio Valley.

R. tersa (Sardeson) (**138**—19, 20). Transversely elliptical in outline; up to 18 mm wide; sides narrowly rounded; anterior subtruncate; hinge very narrow, beak pointed. **U. Ord.:** Ill. (Maquoketa), Minn., Ia. (Maquoketa), Wyo.; Man.

R. corpulenta (Sardeson) (**138**—8, 9). **U. Ord.** (Maquoketa): U. Mississippi Valley.

AULACELLA Schuchert and Cooper 1931

(**Orthis eifelensis* Verneuil). Resembling *Resserella* externally but with convex dorsal valve and shorter ventral muscle scars. **Dev.** (N. Y., Appalachians, Ia., N. Mex.).

A. infera (Calvin) (**138**—24–27). **U. Dev.:** N. Y. (Chemung), Ia. (Independence).

DALMANELLA Hall and Clarke 1892

(**Orthis testudinaria* Dalman). Small to medium sized, subcircular, biconvex, the ventral valve having the greater convexity; multicostellate; ventral muscular area heart-shaped; dorsal interior with prominent median ridge to which the brachiophore supports are attached; brachiophores long and slender; cardinal process lobed; fulcral plates present. **L. Sil.** (Ill., Mo.).

D. edgewoodensis Savage (**138**—28–30). Subcircular in outline, hinge narrower than greatest shell width near middle; ventral valve medially subcarinate, beak incurved; dorsal valve with sulcus extending from beak to margin. **L. Sil.** (Edgewood) Ill., Mo.

Although many brachiopods have been assigned to the genus *Dalmanella* — a genus lamentably broad in its interpretation — *D. edgewoodensis* at present is the only named American species conforming strictly to the type.

LEVENEA Schuchert and Cooper 1931

(**Orthis subcarinata* Hall). Fairly large, subcircular to subquadrate in outline; ventral fold strong; dorsal sulcus deep; ventral muscular area deeply impressed diamond-shaped, with elevated adductor track; dorsal adductors elevated on an elliptical platform. **Sil., Dev.** (L. Onondaga). (N. Y., Appalachians, W. Tenn., Mo., Okla.).

***L. subcarinata** (Hall) (**138**—21–23). **Dev.** (New Scotland and equivalents): Distribution same as genus.

CARINIFERELLA Schuchert and Cooper 1931

(**Orthis carinata* Hall). Large, subelliptical in outline; narrow ventral fold, deep dorsal sulcus; muscular area of ventral valve bilobed and with elevated adductor track; dorsal interior as in *Resserella* but with small cardinal process. **U. Dev.** (Appalachians from Pa. to southern Va.).

C. tioga Hall (**138**—34–38). Broadly elliptical, length two-thirds the width; fold and sulcus not strong. **Chemung:** N. Y., Appalachians.

PARMORTHIS Schuchert and Cooper 1931

(**Orthis elegantula* Dalman). Finely costellate, ventral valve deep and strongly convex, dorsal valve concave to slightly convex; ventral interior with thick dental plates and deep delthyrial cavity; dorsal valve with thickened, shield-shaped adductor field. **M. Sil.** (Que.; N. Y., Appalachians, W. Tenn., Midwest, Okla.).

P. waldronensis (Foerste) (**138**—31–33). Longitudinally elliptical, length (18 mm) slightly greater than width (17 mm); ventral valve subcarinate; beak strongly incurved; sulcus shallow. **M. Sil.** (Waldron): N. Y., Ind., W. Tenn., Okla.

MENDACELLA Cooper 1930

(**Orthis uberis* Billings). Suggesting *Rhipidomella* but valves subequally convex; ventral valve with strong dental plates, muscle area bilobed with long

PLATE 138

[All figures are x1 and original by Cooper unless otherwise indicated.]

1, 2. Linoproductus oklahomae. V ext; Imp D ext. **3–5. Institella leonardensis.** D ext; V and D ints. **6–20. Resserella** spp. **6, 7. R. rogata.** D exts (x1, x2). **8, 9. R. corpulenta.** V and D exts. **10. R. fertilis.** D. ext. **11–14. R. meeki.** V and D exts; V and D ints (x2) [Peabody Mus N H, M 4]. D int and ext (x2). **15–18. R. multisecta.** D and V ints (x2); V and D exts. **19, 20. R. tersa** [Peabody Mus N H, M 4]. D int and ext (x2). **21–23. Levenea subcarinata.** D int (x2); V int; D ext. **24–27. Aulacella infera.** D and V ints (x2); D and Post views. **28–30. Dalmanella edgewoodensis.** V and D exts; D int (x2). **31–33. Parmorthis waldronensis.** D and S views; D int (x2). **34–38. Cariniferella tioga.** D and V exts; Imp D int and squeeze from same; Imp V int. **39–42. Mendacella uberis.** 39. V ext (x1.5) [Peabody Mus N H, M 4]; 40. D ext; 41, 42. D and V ints [CGS, M 154]. **43–45. Prorichthofenia uddeni.** S view; D int; apertural view showing Dv in place. **46–48. Paurorthis catawbensis** (x2). D int and ext; small slab with Imp Dv and Vv. **49. Bilobites varicus** D ext (x2). **50, 51. Bilobites bilobus** [Pal N Y 8]. D and V views (x2).

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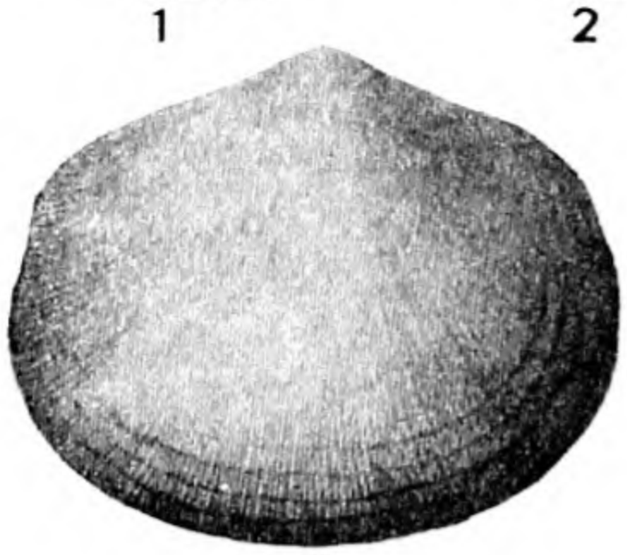
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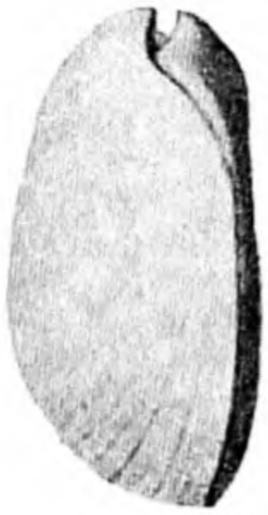
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and narrow diductors; dorsal valve with stout median ridge, thick brachiophores and small lobate cardinal process. **U. Ord., Sil.** (Anticosti; Ont.; N. Y., Ohio, Ky.).

***M. uberis** (Billings) (**138**--39–42). **U. Ord., Sil.:** Anticosti.

PAURORTHIS Schuchert and Cooper 1931

(**Orthambonites parva* Pander). Generally small, subcircular, externally suggesting *Resserella* but having a short subcordate ventral muscular field and pallial impressions like those of *Hesperorthis*; dorsal valve with poorly developed cardinal process, simple brachiophores supported by callus, but an elevated median septum. **M. Ord.** (Holston through Ottosee) (S. Appalachians).

P. catawbensis Butts (**138**—46–48). **M. Ord.:** S. Appalachians.

BILOBITES King 1850

(**Anomia biloba* Linnaeus). Small, bilobed, narrow-hinged; unequally biconvex, costellate; dorsal valve with ponderous cardinalia and thick cardinal process. **U. Ord.–L. Dev.** (Que.; N. Y., Appalachians, W. Tenn., Midwest, Okla.).

***B. bilobus** (Linnaeus) (**138**—50, 51). **M. Sil.** (Niagaran): Widespread throughout N. America.

B. varicus (Conrad) (**138**—49). **L. Dev.** (Coeymans–New Scotland): N. Y., W. Tenn., Okla.

PLATYORTHIS Schuchert and Cooper 1931

(**Orthis planoconvexa* Hall). Circular in outline, plano-convex in lateral profile, costellate; ventral muscular field large and flabellate; dorsal cardinal process with long shaft and erect myophore. **Sil., Dev.** (Onondaga) (Que.; N. Y., Appalachians).

***P. planoconvexa** (Hall) (**139**—1–4). **Helderberg** and **Oriskany:** Same distribution as genus.

RHIPIDOMELLA Oehlert 1890

(**Terebratula michelini* L'Eveillé). Generally circular in earlier forms, becoming subtriangular in later ones; compressed biconvex, finely costellate; hinge very narrow; ventral interior with large flabellate muscular field; dorsal valve with thick brachial processes and large bilobed cardinal process. **M. Sil.–Perm.** (widespread).

R. hybrida (Sowerby) (**139**—5–7). Broadly elliptical in outline, margins rounded; hinge very narrow; valves subequal in depth; ventral muscular area small and oval. **M. Sil.:** N. Y., Ohio, Ind., Wis., Ill., W. Tenn.

R. oblata Hall (**139**—16, 17). Large, transversely subelliptical; width 38 mm, length 31 mm; ventral muscular area large. **L. Dev.:** Que.; N. Y. (New Scotland), Appalachians, W. Tenn., Mo., Okla.

R. musculosa (Hall) (**139**—8–10). Large, with ventral muscular field occupying nearly the entire inner surface. **L. Dev.** (Oriskany): Que.; N. Y., Appalachians, Midwest, Okla.

R. penelope (Hall) (**139**—21–23). Large, nearly circular, diameter about 38 mm; ventral valve flat to gently concave; muscular area nearly circular, width about half the valve width; dorsal valve moderately convex. **M. Dev.** (Hamilton): Ont.; N. Y., Pa.

R. oweni Hall and Clarke (**139**—18–20). Large, circular to transversely elliptical; length 38 mm, width 44 mm; ventral muscular area small. **Miss.:** Ky.

R. carbonaria (Swallow) (**139**—24–26). Small, longitudinally oval in outline, length attaining 12 mm; sides rounded, front subtruncate; dorsal valve much deeper than ventral. **Penn.:** Ill., Ia., Mo., Neb., Kan., Tex.

PERDITOCARDINIA Schuchert and Cooper 1931

(**Orthis dubia* Hall). Like *Rhipidomella* internally and externally but with interareas obsolete and hinge very narrow. **Miss.** (Warsaw to Ste. Genevieve) (S. Appalachians, Midwest, southwestern U. S. A., and adjacent Mex.).

***P. dubia** (Hall) (**139**—30–34). Same range and distribution as genus.

HETERORTHIS Hall and Clarke 1892

(**Orthis clytie* Hall). Large, finely costellate; dorsal valve flat, ventral valve gently convex and internally with long, divergent, elongate and flabellate diductor scars that reach beyond middle of valve; dorsal valve with chilidium, carinate cardinal process and under the brachial processes callus thickenings that are extended around sides of adductor field. **M. Ord.** (Trenton) (S. Appalachians, Ky., Tenn.).

***H. clytie** (Hall) (**139**—27–29). Same range and distribution as genus.

REUSCHELLA Bancroft 1928

(**R. semiglobata*). Large, ventrally carinate, dorsally sulcate, fascicostellate; ventral muscular area bilobed with deeply sunk adductor track; dorsal interior with brachial processes supported by callus deposited in notothyrial cavity. **M. Ord.** (eastern N. America).

R. edsoni (Bassler) (**139**—40–42). **M. Ord.:** Vt. (Glens Falls), ?N. J. (Jacksonburg), Pa. and Va. (Chambersburg).

PLATE 139

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–4. Platyorthis planoconvexa. V and D exts; Imp V int; D int. **5–26. Rhipidomella spp. 5–7. R. hybrida.** V, D, and S views. **8–10. R. musculosa** [Md G S, L Dev]. V and S views; V int. **11–15. R. missouriensis** [Ill G S, M 1]. V, D, and S views; D and V ints. **16, 17. R. oblata.** D and V exts. **18–20. R. oweni** [Ill G S, M 1]. V ext; V int; D int. **21–23. R. penelope.** V and D exts; V int. **24–26. R. carbonaria,** V, D, and S views. **27–29. Heterorthis clytie.** D ext; D and V ints. **30–34. Perditocardinia dubia.** V, D, and S views; D and V ints. **35–39. Fascifera subcarinata** (x2). V and D exts; V and D ints. **40–42. Reuschella edsoni.** V ext; Imp V int; exfoliated Dv. **43–49. Pionodema spp. 43–45. P. minuscula.** V, D, and S views. **46–49. P. subaequata.** D and S views; D and V ints. **50. Isorthis perelegans.** D ext. **51–53. Isorthis arcuaria.** D ext; V and D ints (x2). **54–56. Schizophoria australis** [USGS, B 391]. Ant, Post, and V views.

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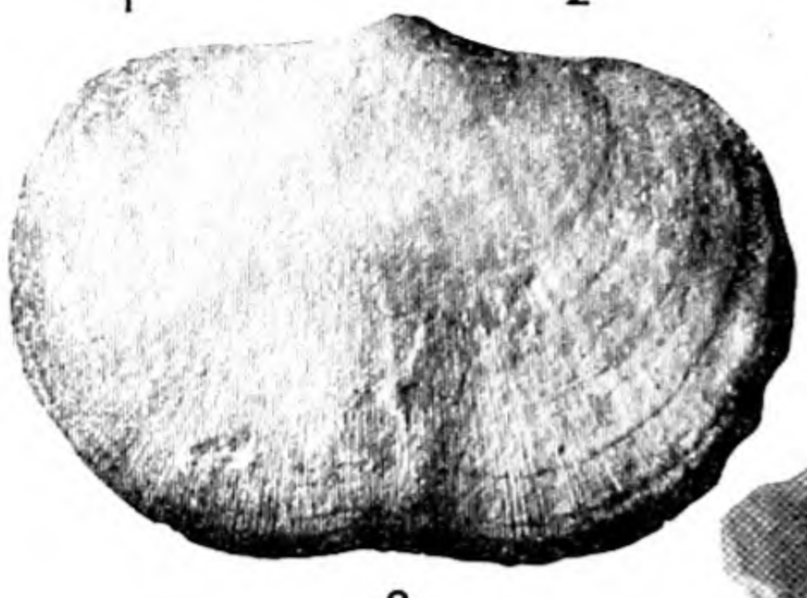
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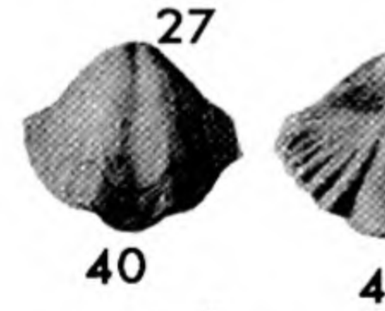
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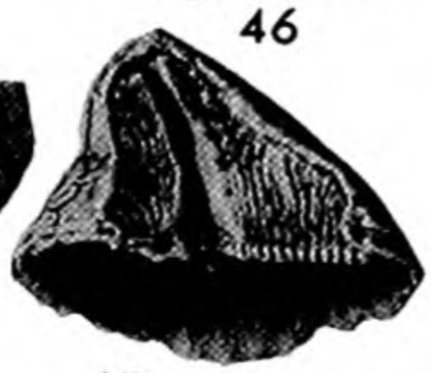
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PIONODEMA Foerste 1912 (**105**—18)

(**Orthis subaequata* Conrad). Semielliptical in outline, strongly biconvex, costellate with some costellae swollen and hollow; ventral interior with small apical plate in delthyrium, elongate diductors and slightly elevated elongate adductor track; dorsal interior with long stout brachial processes supported by divergent plates uniting with floor of valve; sockets defined by fulcral plates. **M. Ord.** to **L. Sil.** (Que., Ont.; N. Y., Appalachians, Tenn., Mississippi Valley).

P. minuscula (Willard) (**139**—43–45). Small, wider than long, width about 13 mm; ventral valve slightly deeper than dorsal; ventral interarea moderately long, beak slightly incurved; costellae fine. **M. Ord.** (Lebanon): Va., Tenn.

***P. subaequata** (Conrad) (**139**—46–49). Large, subrectangular in outline, with hinge slightly narrower than midwidth; attains a width of 22 mm; anterior commissure broadly uniplicate. **M. Ord.** (Black River, L. Trenton): N. Y., S. Appalachians, Mississippi Valley.

FASCIFERA Ulrich and Cooper 1942

(**F. subcarinata*). Exterior like *Resserella* with subcircular outline, deep ventral and shallow dorsal valve; multi-fascicostellate; interior like *Pionodema*. **M. Ord.** (Ottosee, Trenton) (S. Appalachians, Minn.).

***F. subcarinata** U and C (**139**—35–39). **M. Ord.:** S. Appalachians.

ISORTHIS Kozlowski 1929

(**Dalmanella* (*Isorthis*) *szajnochai*). Costellate, biconvex and with interior of *Schizophoria*. **M. Sil.** to **L. Dev.** (Que.; N. Y., Appalachians, W. Tenn., Okla.).

I. arcuaria (Hall and Clarke) (**139**—51–53). Small, strongly convex, finely costellate; ventral interior with strongly impressed muscular field, narrow elongate diductor scars, and divergent pallial impressions. **M. Sil.:** W. Tenn. (Beech River).

I. perelegans (Hall) (**139**—50). Shell large, nearly circular, with diductors separated by a narrow elevated adductor ridge suggesting *Schizophoria*. **Helderberg** (New Scotland): N. B., Que.; N. Y., Appalachians, W. Tenn., Okla.

SCHIZOPHORIA

King 1850 (**106**—1, 2; **140**—4, 5)

(**Conchyliolithus Anomites resupinatus* Martin). Interior of dorsal valve like *Pionodema* but ventral interior having divergent diductor scars separated by an elevated adductor ridge; ventral valve generally concave at front; dorsal valve strongly convex; finely costellate. **M. Sil.–Perm.** (widespread throughout N. America).

S. multistriata (Hall) (**140**—10, 11). Subcircular in outline, slightly wider (28 mm) than long (25 to 28 mm); ventral sulcus very short and shallow; surface finely costellate. **L. Dev.:** N. B.; N. Y. (Becraft), Appalachians.

S. nevadaensis Merriam (**140**—6, 7). Thick-shelled, subrectangular in outline, wider (38 mm) than long (34 mm); front margin truncated; both valves somewhat sulcate or dorsal valve flattened at front. **L. Dev.:** Nev. (L. Nevada).

S. macfarlani (Meek) (**140**—1–3). Length slightly greater than width (25 mm); hinge scarcely equal to half greatest width; dorsal valve strongly convex; pallial impressions strong on fillings of interior. **M.** and **U. Dev.:** N. Y.; NWT., Canada.

S. australis Kindle (**139**—54–56). Very large, subrectangular to subelliptical, about 50 mm wide, 38 mm long; strong sulcus at front third of ventral valve; dorsal fold appearing only at front. **U. Dev.:** Colo. (Ouray), N. Mex. (Percha), Ariz.

S. swallovi (Hall) (**140**—8, 9). Large, width about 50 mm, length 38 mm; ventral valve nearly flat, median sulcus broad, shallow, and undefined; dorsal valve strongly convex, with median flattened and sulcate area. **Miss.** (Burlington): Mississippi Valley.

ENTELETES Fischer 1825 (**140**—12–15)

(**Enteletes choristites*). Globular in outline and profile, coarsely plicate with plications and interspaces covered with fine radial lines; ventral interior with two subparallel thin dental plates and a high median septum; dorsal valve with long curved brachial processes; flaring supporting plates; small cardinal process and fulcral plates defining the sockets. **Penn., Perm.** (Mississippi Valley, Okla., Tex., southwestern U. S. A.).

E. hemiplicatus (Hall) (**140**—16–18). **Penn.:** Neb., Kan., Okla., ?Tex.

PARENTELETES King 1930

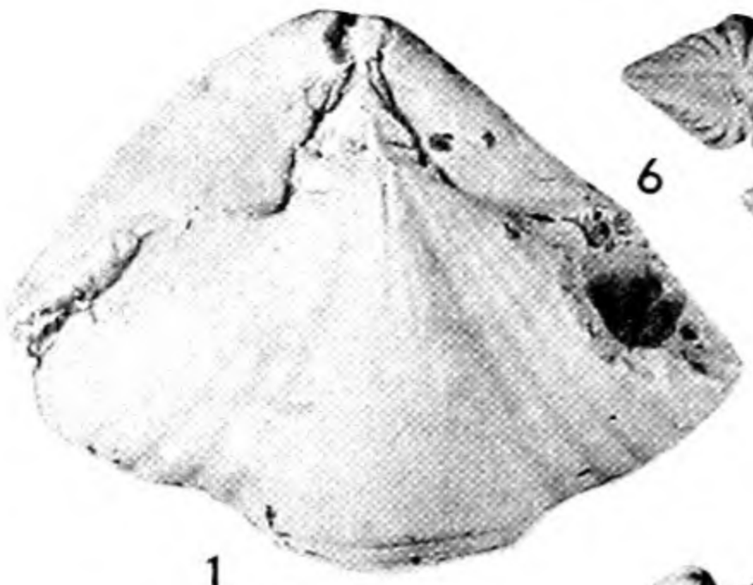
(**P. cooperi*). Resembling *Enteletes* but having a strong fold on ventral valve and a deep sulcus on dorsal; ventral interior with inverted V-shaped chamber under median septum; dorsal interior like *Enteletes*. **Penn., Perm.** (Gaptank to L. Leonard) (Kan., W. Tex.).

***P. cooperi** King (**140**—21–23). **Penn.:** Kan., W. Tex.

PLATE 140

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–11. Schizophoria spp. **1–3. S. macfarlani.** V and S views; Imp D int. **4, 5. S. iowensis** [Peabody Mus N H, M 4]. D int showing fulcral plates. **6, 7. S. nevadaensis.** V and D exts of two specimens. **8, 9. S. swallovi** [Ill G S, M 1]. V ext; Imp V int. **10, 11. S. multistriata.** D and S views. **12–15. Enteletes** sp. (x2). Two views of a D int and a V int. **16–18. Enteletes hemiplicatus.** D, S, and V views. **19, 20. Tropidoleptus carinatus.** V and D exts. **21–23. Parenteletes cooperi** [Peabody Mus N H, M 4]. V ints (x1, x2); S view. **24–26. Rhynchopora taylori** [USGS, B 436]. D ext; V ext (x2); S view. **27–30. Rhynchopora magnicosta.** V, D, Ant, and S views. **31–42. Cyrtina** spp. **31–34. C. acutirostris** [Ill G S, M 1]. V, D, Post, and S views. **35, 36. C. alpenensis.** V and D exts. **37–39. C. "hamiltonensis."** Post, V, and D views. **40–42. C. umbonata.** V, D, and S views. **43–51. Spondylospira** spp. **43–47. S. reesidei.** Int, ext, and Post of Vv; int and ext of Dv. **48–51. S. alia.** V, Post, Ant, and S views. **52–55. Pseudoidea** sp. V, D, Post, and S views.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TROPIDOLEPTUS Hall 1857

(**Strophomena carinata* Conrad). Subquadrate in outline, concavo-convex in profile, surface marked by broad, rounded costae; wide-hinged; dorsal valve with high median septum to which ends of brachial processes are united. **Dev.** (Hamilton through Chemung) (N. Y., Appalachians, N. Mex. [Chemung]).

***T. carinatus** (Conrad) (**140**—19, 20). Range and distribution same as genus.

RHYNCHOPORA King 1865

(**Terebratula geinitziana* Verneuil). Subtriangular to subpentagonal in outline; subtriangular in profile; costate; ventral valve with long flattened tongue; exterior punctate, punctae large; dental plates well developed; dorsal interior with undivided hinge plate supported by a Y-shaped plate making a cruralium under hinge plate; crura extending directly anteriorly. **Miss.–Perm.** (Ind., Ill., Midcontinent, Tex., Wyo., Great Basin, Ore.).

R. taylori Girty (**140**—24–26). Large, subpentagonal, fold and sulcus wide; sulcus with 5 costae; flanks with 11 costae. **Perm.:** Tex., Idaho.

R. magnicosta Mather (**140**—27–30). Pentagonal in outline, profile triangular; costae wide and rounded; fold with six to eight costae, sulcus with five to seven; flanks with five to six costae. **L. Penn.:** Ark. (Brentwood), Okla. (Morrow), Tex. (Bend).

PUNCTOSPIRACEA (*nov.*). Endopunctate brachiopods having a spiral brachidium.

CYRTINA Davidson 1858

(**Calceola heteroclita* Defrance). Spiriferoid, small to middle sized, costate, with hemipyramidal ventral valve having a long, often deformed interarea; small slightly convex dorsal valve with prominent median fold; delthyrium covered with a convex pseudodeltidium? bearing a large foramen near apex; ventral interior with spondylium, the median septum appearing as a ridge in the spondylium; dorsal interior with spire like *Spirifer* and having complete jugum. **M. Sil.–L. Miss.** (widespread throughout N. America).

C. hamiltonensis (Hall) (**140**—37–39). Triangular-subpyramidal; hinge wide; cardinal extremities often acuminate; length and width nearly equal; length of interarea often equal to length of dorsal valve, fold broad and subangular; five to eight costae on flanks. **M. Dev.** (Hamilton, Traverse): Ont.; N. Y., Appalachians, Mich., Ohio, Ind., Ky., Mississippi Valley.

C. umbonata (Hall) (**140**—40–42). Differs from preceding by its more acute extremities, smaller size, more rounded fold, and strongly incurved beak. **M. Dev.:** Mich., Ia. (Cedar Valley).

C. alpenensis Hall and Clarke (**140**—35, 36). Resembling the preceding by its strongly incurved beak, but much larger, attaining a width of 25 mm or more. **M. Dev.:** Mich. (Traverse).

C. acutirostris (Shumard) (**140**—31–34). **Miss.** (Kinderhook): Mississippi Valley.

PSIOIDEA Hector 1879

(**Spiriferina suessi australis* Trechmann). Medium sized to large and costate; cyrtinoid with smooth fold and sulcus; ventral interior as in *Spondylospira*. **Trias.** (Nev., Cal.; Alaska) (American representative [**140**—52–55]).

SPONDYLOSPIRA Cooper 1942

(**S. reesidei*). Cyrtinoid, with convex dorsal valve, fold and sulcus costate, ventral valve hemipyramidal; interarea long, hinge margins denticulate; delthyrium open; ventral interior with cyrtinoid spondylium; crural bases small, descending lamellae of spire supported by a calcareous net. **Trias.** (Idaho, Nev., Cal.; Yukon region, Alaska).

***S. reesidei** Cooper (**140**—43–47). Small, strongly costate; dorsal fold defined posteriorly by a single costa which bifurcates twice to produce four costae near the middle. **U. Trias.:** Idaho.

S. alia (Hall and Whitfield) (**140**—48–51). Larger than preceding and with much finer costae. **U. Trias.:** Nev.

DIMEGELASMA Cooper 1942

(**Spirifer neglectus* Hall). Shell large, costate, with noncostate fold and sulcus; delthyrium covered with a flat pseudodeltidium?; ventral interior with long dental plates; ventral muscular area elongate; dorsal interior with short median septum supporting a concave hinge plate. **Miss.** (Ky., Tenn., Ala., Ill., Ia., Mo., Okla.).

***D. neglectum** (Hall) (**141**—1–5). **Keokuk:** Tenn., Ala., Mississippi Valley, Okla.

PUNCTOSPIRIFER North 1920

(**P. scabricosta*). Generally small, wide-hinged, flanks costate but fold and sulcus noncostate; surface imbricate and pustulose; dental plates strong; median septum long and high; jugum V-shaped, and directed posteroventrad. **Miss.–Perm.** (S. Appalachians, Ind., Ky., Tenn., Ill., Mo., Midcontinent,

PLATE 141

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–5. Dimegelasma neglectum. D and S views of Int F; V int; D ints. **6–8. Punctospirifer** spp. **6, 7. P. kentuckiensis.** Post and D views of ext. **8. P. pulcher.** D ext. **9–13. Reticularlina spinosa.** D ext showing spines (x2); V and D exts; D ext; V int. **14–18. Rhynchospirina formosa.** V, D, and S views; D ints. **19–24. Trematospira** spp. [Pal N Y 8 (2)]. **19, 20. T. camura.** V and D exts. **21–24. T. gibbosa.** V, D, Post, and Ant views. **25–27. Homoeospira evax.** V, D_t and S views. **28–30. Trematospira multistriata.** D ext; Post view of cardinal process; spiralium and jugum [Pal N Y 8 (2)]. **31. Trematospira** sp. D int (x2). **32–34. Parazyga hirsuta.** V, D, and S views. **35–41. Eumetria** spp. [Ill G S, M 1]. **35–37. E. altirostris.** D, S, and Ant views. **38–41. E. vera.** Ant, V, S, and D views. **42. Eumetria** sp. D int (x3). **43–48. Hustedia** spp. **43–45. H. mormoni.** V, D, and S views. **46–48. H. hessensis.** D, V, and S views. **49–52. Amphigenia elongata.** D and V ints; D and S views. **53–55. Amphigenia curta** [Ill G S 3]. Post, D, and V views of Int F. **56, 57. Centronella glansfagea.** V and S views. **58–61. Centronella impressa.** D int (x2); V and D exts; small slab showing impressions of V int.

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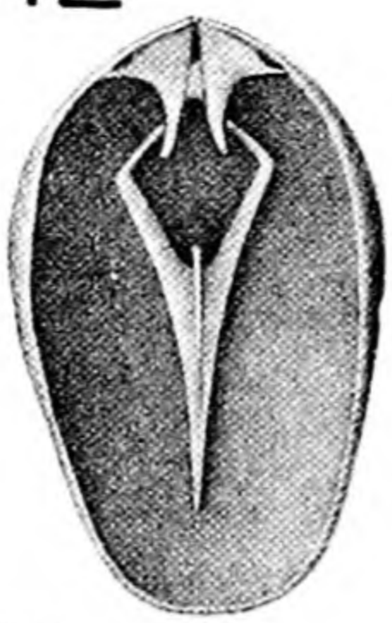
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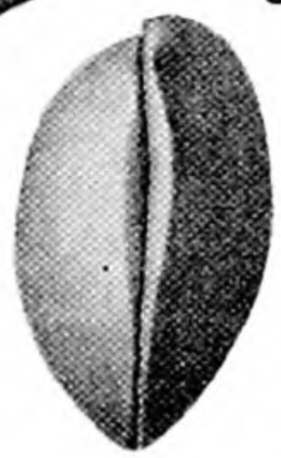
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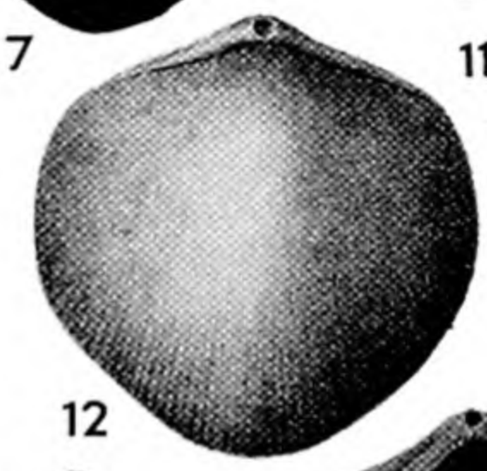
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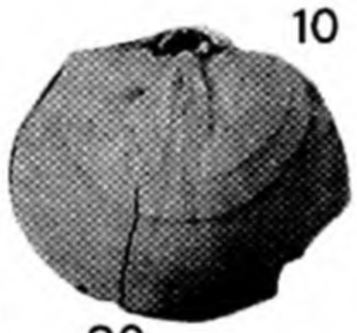
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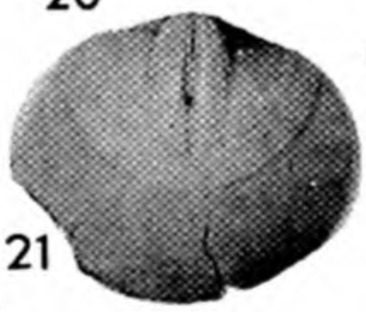
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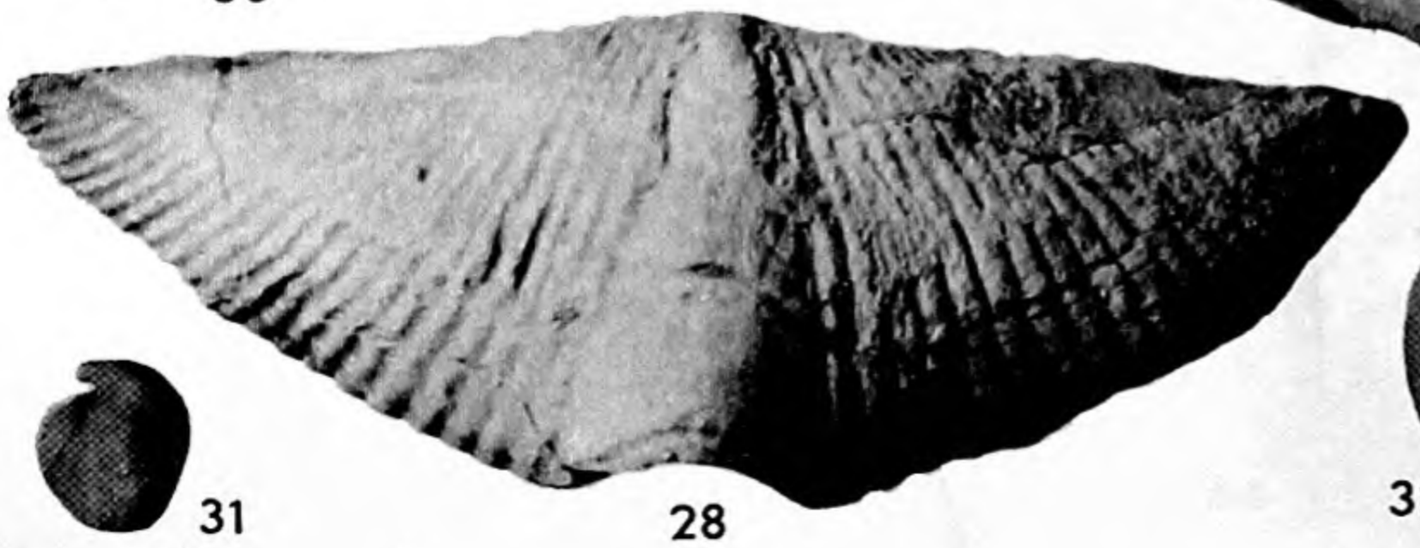
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Tex., Rocky Mts. of Canada and U. S. A., Great Basin).

P. kentuckiensis (Shumard) (**141**—6, 7). Small, variable, narrow- or wide-hinged, the latter types approaching 25 mm in width; length half the width; fold narrowly rounded; cardinal extremities narrowly rounded to acutely pointed; interarea long, nearly flat, about at right angles to plane of valve contact; beak slightly incurved; lamellae finely fimbriate, closely spaced, five in 1 mm. **Penn.:** Ill., Mo., Neb., Kan., Okla., Tex.

P. pulcher (Meek) (**141**—8). Large, wide-hinged; attaining a width of about 75 mm and a length of about 25 mm; cardinal extremities mucronate; fold low and rounded; flanks with eight narrowly rounded costae. **Perm.** (Phosphoria): ?Tex., Wyo., Idaho.

RETICULARIINA Fredericks 1916

(**Spirifer spinosa* Norwood and Pratten). Punctate spiriferids resembling *Punctospirifer* but with surface covered with scattered spines. **U. Miss.** (Chester) (Ky., Tenn., Ala., Ill.).

***R. spinosa** (N and P) (**141**—9–13). **Chester:** Ky., Tenn., Ala., Ill.

RHYNCHOSPIRINA Schuchert and LeVene 1929

(**Waldheimia formosa* Hall). Elongate-ovate, with circular foramen; costae low; valves subequal in depth; deltidial plates flat; ventral interior without dental plates; dorsal interior with thick median septum supporting a ponderous hinge plate, much thickened and with two triangular processes extending posterodorsally over each side of dorsal umbo; crural bases stout; spire with six to nine volutions; primary lamellae narrow and not greatly incurved; jugum situated behind middle of lamellae, forming an inverted V. **U. Sil.** to **L. Dev.** (N. Y., Appalachians, W. Tenn., Mo., Okla.).

***R. formosa** (Hall) (**141**—14–18). **Dev.** (New Scotland): Same distribution as genus.

HOMOEOSPIRA Hall and Clarke 1893

(**Rhynchospira evax* Hall). Externally like *Rhynchospirina* but dorsal valve having a high median septum, the hinge plate having no posterior extension but with greatly extended anterior lobes; jugum with more acute stem. **M. Sil.** (N. Y., Ind., W. Tenn.).

***H. evax** (Hall) (**141**—25–27). **Waldron:** N. Y., Ind., W. Tenn.

TREMATOSPIRA Hall 1857 (**141**—31)

(**Spirifer multistriatus*). Transverse, costate to multicostate, rostrate with circular foramen, uniplicate; ventral interior with dental plates and flabellate muscular area; dorsal hinge plate ponderous with upper quadrate face divided by a longitudinal groove and a transverse groove, thus creating two posterior parts that project into ventral delthyrial cavity and two anterior parts that bear the crura; jugum V-shaped with end of V projecting posteriorly. **M. Sil.** to **M. Dev.** (N. B., Que., Ont.; N. Y., Appalachians, Ind., Ky., W. Tenn., Ill., Mo.).

T. camura (Hall) (**141**—19, 20). Small, transversely elliptical; hinge narrow; valves subequal in depth; fold low, flat, composed of four costae, the middle two depressed; flanks with five angular costae; entire surface papillose. **M. Sil.:** N. Y., Ind., W. Tenn.

***T. multistriata** (Hall) (**141**—28–30). Large, spiriferoid, hinge narrow, sides narrowly rounded; fold low, broad, sulcus wide and shallow; multicostellate. **L. Dev.:** N. Y. (New Scotland), Appalachians, W. Tenn., Okla.

T. gibbosa (Hall) (**141**—21–24). Small, transversely elliptical; fold with three costae, sulcus with two; flanks marked by four costae. **M. Dev.** (Marcellus–Tully): N. Y., Pa., Mich., Ind.

PARAZYGA Hall and Clarke 1893

(**Atrypa? hirsuta* Hall). Transverse, uniplicate, multicostate to multicostellate with exterior covered with very fine spines; ventral interior with dental plates and incomplete pedicle collar; hinge plate narrow, with two widely separated vertical supports which have their origin on the downward umbonal slope of the shell; these supports widely separated at bases, enclosing marginal dental sockets, anterior faces vertical, upper surfaces small and subtriangular; jugum as in *Trematospira*. **L?.** to **M. Dev.** (Ont.; N. Y., Pa., Mich., Ind.).

***P. hirsuta** (Hall) (**141**—32–34). **Hamilton:** Distribution same as genus.

EUMETRIA Hall 1864 (**141**—42)

(**Retzia vera*). Elongate-ovate in outline, biconvex, rostrate, foramen circular, valves costate to costellate; no dental plates in ventral valve; dorsal cardinal extremities auriculate; dorsal interior with complex hinge plate supported by two divergent lamellae. **Miss.** (widespread throughout U. S. A.).

E. altirostris White (**141**—35–37). Strongly costate. **Miss.** (Kinderhook and equivalents): Pa., Mississippi Valley.

***E. vera** (Hall) (**141**—38–41). Large, length and width nearly equal; finely costate. **U. Miss.** (Chester): Mississippi Valley.

PLATE 142

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–4. Rensselaeria spp. 1, 2. R. elongata, V and S views. **3, 4. R. marylandica** [Pal N Y 8 (2)]. Views showing loop. **5–7. Etymothyris gaspensis.** D and S views of large individual; D view of Int F. **8, 9. Subrensselandia claypolli.** V and D views of Int F. **10–14. Beachia suessana.** Ant, S, and D views; D int showing loop. **15. Rensselandia johanni** [JP 15]. D ext. **16–19. Prionothyris perovalis.** S and D views; D and V ints. **20, 21. Prionothyris condoni.** D and V views of Int F. **22–26. Cryptonella spp. 22. C. attenuata.** D ext (x2). **23–26. C. rectirostra.** V, D, and S views; D int showing loop (x2) [original by P. E. Cloud]. **27–29. Syringothyris texta.** Post, D, and Ant views. **30–33. Cranaena spp. 30, 31. C. romingeri.** D and S views. **32, 33. C. iowensis.** S and D views.

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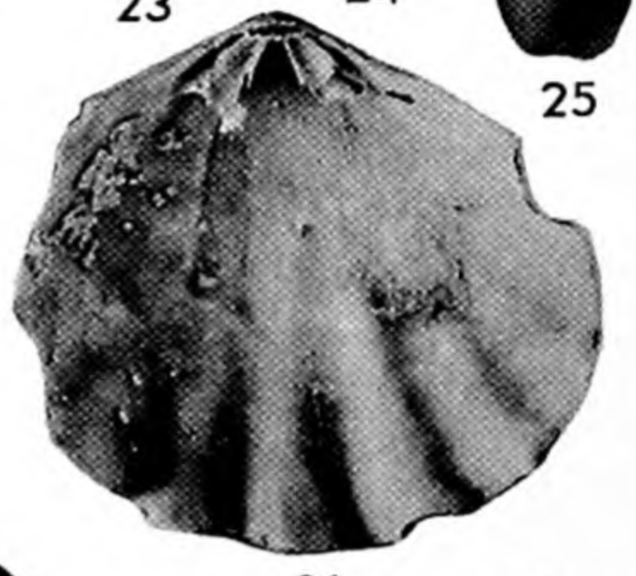
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HUSTEDIA Hall and Clarke 1893

(**Terebratula mormoni* Marcou). Generally small, terebratuliform, costate; flat symphytium; ventral interior with incomplete pedicle collar; dental lamellae absent, hinge plate erect, brachial supports extending directly ventrad far into ventral valve and between them appears a median curved process extending from dorsal umbonal cavity into ventral valve; limbs of V-shaped jugum broad, often fimbriate. **Miss.–Perm.**

***H. mormoni** (Marcou) (**141**—43–45). Small, oval in outline, with about 15 costae. **Penn.:** Widespread throughout N. America.

H. hessensis King (**141**—46–48). **Perm.:** W. Tex. (Leonard).

SYRINGOTHYRIS Winchell 1863

(* *S. typa*). Usually large with ventral valve semipyramidal; fold and sulcus noncostate; entire surface covered with minute pustules; ventral interior with long divergent dental plates; delthyrium partly covered with a flat apical plate from which the syrinx, an accessory muscular attachment, extends into interior; dorsal interior as usual in the spiriferoids; shell substance endopunctate. **U. Dev.** to **Miss.** (Conewango–Keokuk) (N. Y., Pa., Appalachians, Tenn., Mississippi Valley, Rocky Mts., Great Basin).

S. texta (Hall) (**142**—27–29). Very large, with greatest width at hinge; interarea at right angles to commissure and nearly flat; flanks bounding sulcus marked by 18 to 24 costae. **Miss.** (Keokuk): Va., Ind., Ky., Ill., Ia.

TEREBRATULACEA. Endopunctate brachiopods having lophophore supported by a brachidium in the form of a more or less complicated loop.

CENTRONELLA Billings 1859

(**Rhynchonella glansfagea* Hall). Small, rhomboidal in outline, ventral valve longitudinally subcarinate; dorsal valve concave, surface smooth; ventral interior with thick dental plates and large teeth; dorsal valve with ponderous divided hinge plate; loop short, the descending lamellae meeting a short longitudinal plate. **Dev.** (Onondaga to Tully) (Que., Ont.; N. Y., Mich., Ind., Ky., Ill., Ark.).

***C. glansfagea** (Hall) (**141**—56, 57). Small, subrhomboidal in outline, length about 7 mm; ventral beak strongly incurved. **L. Dev.** (Schoharie–L. Onondaga): Ont.; N. Y., Mich.

C. impressa Hall (**141**—58–61). Elongate, rhomboidal in outline, about 16 mm long; beak erect. **M. Dev.** (Hamilton): N. Y., Ind., Ky., Ill., Ark.

AMPHIGENIA Hall 1867

(**Pentamerus elongatus* Vanuxem). Shells large, smooth, elongate, suggesting *Pentamerus* in outline and profile; ventral interior having a long spondylium supported by a median septum; dorsal interior having divided hinge plate and short imperfectly known loop. **Dev.** (Onondaga) (Me.; Ont.; N. Y., Appalachians, Mich., Ky., Tenn., Ill.).

A. curta (Meek and Worthen) (**141**—53–55). Small, oval in outline, rhomboidal in section; differs from *A. elongata* in more rounded outline and smaller size. **Dev.** (Onondaga): Appalachians, W. Tenn., Ill., Mo.

***A. elongata** (Vanuxem) (**141**—49–52). Large, elongate, pentagonal in outline, length up to 10 cm; greatest width posterior to middle; anterior narrow; beak low and incurved. **Dev.** (L. Onondaga): Ont.; N. Y., Pa., Mich., Ohio, Ky.

RENSSELAERIA Hall 1859 (**142**—3, 4)

(**Atrypa elongata* Conrad). Shells generally narrowly elongate, biconvex, with valves subequal in depth; surface costellate; ventral interior having obsolete or obsolescent dental plates and narrow, elongate muscular field; dorsal interior with apically perforate hinge plate supported by short subparallel plates. **L. Dev.** (Oriskany) (Que., Ont.; Me., N. Y., Appalachians, W. Tenn., Ill., Mo.).

***R. elongata** (Conrad) (**142**—1, 2). Large, elongate pentagonal in outline, with shouldered posterior and narrowed anterior; length about 87 mm, width 50 mm; beak low and incurved. **L. Dev.** (Oriskany): N. Y., Appalachians, W. Tenn., Ill., Mo., Okla.

R. marylandica (Hall) (**142**–3, 4.) Smaller and narrower than preceding. **L. Dev.** (Oriskany): Md.

ETYMOTHYRIS Cloud 1942

(**Rensselaeria ovoides gaspensis* Clarke). Like *Rensselaeria*, but with prominent unthickened dental plates converging ventrally. **Dev.** (eastern N. America).

***E. gaspensis** (Clarke) (**142**—5–7). Long and slender, width about half the length; narrowly elliptical in cross-section. **L. Dev.:** Que. (Gaspé).

BEACHIA Hall and Clarke 1893

(**Meganteris suessana* Hall). Subcircular to elongate-oval in outline, subequally convex, smooth to anteriorly costellate; ventral interior having dental plates and elongate-ovate muscular area; dorsal

PLATE 143

[All figures are x1 and original by Cooper unless otherwise indicated.]

1–3. Terebratulina floridana. D and S views; D ext (x2). **4, 5. Stringocephalus "burtini."** V and D views of an Int F. **6–13. Dielasma** spp. **6–8. D. bovidens.** V, D, and S views. **9, 10. D. illinoisense** [Ill G S, M 1]. D and S views. **11–13. D. formosum** [Ill G S, M 1]. S, V, and D views. **14–16. Dielasmella calhounensis** [Ill G S, M 1]. S, V, and D views. **17–20. Heterelasma** sp. S, V, and D views (x2); D int showing loop (x4). **21–23. Girtyella turgida** [Ill G S, M 1]. V, D, and S views. **24–26. Girtyella indianensis** [USNM, Pr 34]. V and D exts; D post showing median septum. **27–31. Plectoconcha aequiplicata.** D view showing foramen; V, S, and D views; D int (x2). **32–34. Kingena wacoensis.** D int showing loop; D and S views. **35–37. Choristothyris plicata.** D ext; Int showing calcite-incrusted loop (x2); D int. **38–40. Argyrotheca johnsoni.** D int (x6); V and D exts (x4). **41. Terebratulina filosa.** D ext (x2). **42, 43. Dallinella obsoleta.** D and S views. **44–49. Oleneothyris hariani.** S and D exts; D int; two views of loop; V int. **50, 51. Terebratalia transversa.** D and V exts.

interior with hinge plate like *Rensselaeria*; loop long with long crural processes, a long spatulate anterior plate from the posteromedian point of which a process extends in a ventral direction. **L. Dev.** (Oriskany) (Que., Ont.; N. Y., Appalachians, Ill., Mo.).

***B. suessana** (Hall) (**142**—10–14). **Oriskany:** Same distribution as genus.

PRIONOTHYRIS Cloud 1942

(**P. perovalis*). Like *Beachia* but with bosslike myophore having lateral serrate depression. **Dev.** (Oriskany–Onondaga) (Ont.; N. Y., Appalachians, W. Tenn., Ill.).

***P. perovalis** Cloud (**142**—16–19). **Oriskanv:** N. Y.

P. condoni (McChesney) (**142**—20, 21). **L. Onondaga:** Appalachians, W. Tenn., Ill.

RENSSELANDIA Hall 1867

(**Rensselaeria? johanni*). Outline and profile like *Rensselaeria* but smooth exterior and long loop. **M. Dev.** (Hamilton) (Pa., Mich., Ia., Mo., Mackenzie Valley).

***R. johanni** (Hall) (**142**—15). Resembles *Subrensselandia claypolii* in size but more rounded laterally. **M. Dev.:** Ia. (Cedar Valley), Mo.

SUBRENSSELANDIA Cloud 1942

(**Rensselaeria claypolii* Hall). Like *Rensselaeria* but with hinge plate supported by lamellae. **M. Dev.** (Hamilton) (Pa., Mo.).

***S. claypolii** (Hall) (**142**—8, 9). Width about half the length, outline oval, narrowing anteriorly; internal impressions strong. **M. Dev.** (Hamilton): Pa., Mo. (Beauvais).

STRINGOCEPHALUS Defrance 1824

(**S. burtini*). Large, generally transverse, ventral valve the deeper of the two, swollen medially; ventral beak long; strongly incurved, suggesting beak of an owl; smooth; ventral interior having a high median septum; dorsal interior having an elongate forked cardinal process; median septum more or less elevated and a long, wide loop. **M. Dev.** (Minn.?; Man; Utah, Nev.; Mackenzie Valley).

***S. "burtini"** type (**143**—4, 5). **M. Dev.:** Mackenzie Valley, Man.; Utah, Nev.

CRYPTONELLA Hall 1861

(**Terebratula rectirostra*). Elongate, valves subequally convex, smooth, ventral beak erect and long; ventral interior having dental plates; dorsal interior with a perforated hinge plate and long loop. **Dev.** (Ont.; N. Y., Pa., Mich., Ind., Ky.).

C. attenuata Whiteaves (**142**—22). Small, flattish, widened anteriorly, narrowed posteriorly, with very long beak. **M. Dev.:** Ont. (Hungry Hollow); northern Ind.

***C. rectirostra** (Hall) (**142**—23–26). Rhomboidal in outline; about 19 mm long, 13 mm wide, beak long, slightly incurved. **M. Dev.** (Hamilton): N. Y., Mich.

HETERELASMA Girty 1908

(**H. shumardianum*). Small, concave ventral valve, convex to subcarinate dorsal valve; hinge plate and loop like *Cryptonella*. **Perm.** (W. Tex.).

H. sp. (**143**—17–20). **Perm.:** W. Tex.

CRANAENA Hall and Clarke 1893

(**Terebratula romingeri* Hall). Valves subequally convex, oval in outline, surface smooth, beak incurved, ventral interior having dental plates; dorsal interior with perforated hinge plate; loop short. **M. Dev.** to **Miss.** (N. Y., Pa., Appalachians, W. Tenn., Mississippi Valley, Midwest, Great Basin).

***C. romingeri** (Hall) (**142**—30, 31). Small, approaching 12 mm in length; beak narrow, strongly incurved; valves subequal in depth, the dorsal valve swollen in mid-region; greatest width at about middle. **M. Dev.** (Hamilton, Tully): N. Y., Mich., Ill., Ia.

C. iowensis (Calvin) (**142**—32, 33). Large, oval in outline, approaching 37 mm in length, over 25 mm in width; valves subequal in depth; beak not elongated, incurved; sides broadly rounded, front subtruncate. **M. Dev.:** ?Mich., Ia. (Cedar Valley), Mo.

C. sulcata Weller. **Miss.** (Warsaw): Mississippi Valley.

DIELASMA King 1859

(**Terebratulites elongatus* Schlotheim). Elongate oval, biconvex, ventral valve often sulcate; ventral interior having dental plates; hinge plate resting on floor of valve and bearing muscular attachments; loop short. **Miss.–Perm.** (all areas of outcrop).

D. formosum (Hall) (**143**—11–13). Large, elongate-oval, greatest width anterior to middle, narrowed posteriorly; beak strongly incurved. **Miss.** (Warsaw): Ind., Ky.

D. illinoisense Weller (**143**—9, 10). Medium-sized, longitudinally elliptical in outline; length nearly twice width. **U. Miss.** (Chester): Ill., Okla.

D. bovidens (Morton) (**143**—6–8). Medium to large, elongate oval in outline; convexi-concave in anterior profile; dorsal valve nearly flat in lateral profile; ventral valve strongly convex and with wide deep sulcus. **Penn., L. Perm.:** Mo., Neb., Kan., Okla., Tex.

DIELASMELLA Weller 1911

(**Eunella compressa*). Small, compressed, ovate, with strong dental plates in ventral valve; hinge plate short, attached to sides of valve by short plates; dorsal foramen large; plate uniting socket ridges short. **U. Dev., L. Miss.** (S. Ind., Mississippi Valley).

D. calhounensis Weller (**143**—14–16). Small, compressed, oval to subpentagonal in outline; narrowly lenticular in profile; beak erect; internal impressions moderately strong on fillings. **Miss.** (Kinderhook): Ind., Ill.

GIRTYELLA Weller 1911

(**Harttina indianensis* Girty). Shells generally small,

subequally convex, ventral valve sulcate; dorsal valve sinuate or medially plicate; ventral valve having dental plates; dorsal interior having an imperforate, concave hinge plate supported by a short median septum. **Miss.** (Ind., Ill., Ky., Mo.).

***G. indianensis** (Girty) (**143**—24–26). Small, about 12 mm long, widest in anterior half, narrowed posteriorly; valves subequal in depth; ventral sulcus narrow, shallow; fold scarcely discernible. **Miss.** (Ste. Genevieve): Ind., Ky., Ill., Ia.

G. turgida (Hall) (**143**—21–23). Small, with strongly incurved beak and inflated dorsal valve; both valves sulcate, producing an emarginate anterior; dorsal sulcus often with low fold. **Miss.** (Warsaw): Ind., Ill., Ky.

G. intermedia Weller. Like the preceding but larger and with stronger dorsal fold. **U. Miss.** (Chester): Ill.

PLECTOCONCHA Cooper 1942

(**Rhynchonella aequiplicata* Gabb). Small to large, elongate oval; strongly biconvex; anterior half costate; dental plates absent; dorsal interior with divided hinge plate; short loop with widely divergent descending lamellae and narrow connecting ribbon. **Trias.** (B. C.; Nev., Cal.).

***P. aequiplicata** (Gabb) (**143**—27–31). **Trias.:** B. C.; Nev., Cal.

TEREBRATULINA Orbigny 1847 (**106**—15)

(**Anomia retusa* Linnaeus). Generally small, biconvex, costellate; foramen large, deltidial plates disjunct; cardinal extremities produced into small ears; dorsal interior with widely separated socket plates to which are attached short descending processes supporting a ring. **Jura.–Recent.**

T. filosa Conrad (**143**—41). Circular to slightly oval in outline, ventral valve strongly convex; dorsal valve nearly flat; ventral interarea long; possibly belongs to genus DISCULINA Deslongchamps 1884 (**Terebratula hemisphaerica* Sowerby). **U. Cret.:** Ala., Tex.

T. floridana (Morton) (**143**—1–3). Oval in outline, about 19 mm long, 13 mm wide; subequally convex; beak short, slightly incurved: costellae very fine. **U. Cret.:** Ala., Miss., Tex.

OLENEOTHYRIS Cooper 1942

(**Terebratula* harlani Morton). Large, elongate-ovate, sulcate; ventral beak erect, foramen large, mesothyrid; ventral interior without dental plates; muscular field large and elongate; hinge plate divided with high socket plates, loop short with V-shaped transverse band, the apex of the V directed posteroventrally. **Eoc.** (N. J., Ala.).

***O. harlani** (Morton) (**143**—44–49). **Eoc.:** N. J.

CHORISTOTHYRIS Cooper 1942

(**Terebratula* plicata Say). Small, subcircular, biconvex, sulcate, multicostate to plicate, foramen large, deltidial plates disjunct; ventral muscular area flabellate; dorsal interior with large trilobate cardinal process having a fairly long shaft, short concave crural bases, high median septum, and loop resembling *Terebratella*. **U. Cret.** (N. J.).

***C. plicata** (Say) (**143**—35–37). **U. Cret.:** N. J.

ARGYROTHECA Dall 1900

(**Terebratula cuneata* Risso). Small, biconvex with ventral valve deeper of the two, costate, foramen very large, deltidial plates disjunct; pedicle collar narrow, elevated, supported by a high median septum; dorsal interior with median septum and loop with branches directed laterally, then curving anterodorsally to join valve floor or median septum. **Eoc.–Recent.** (Atlantic and Gulf Coastal Plain).

A. johnsoni Cooper (**143**—38–40). **Recent.**

TEREBRATALIA Beecher 1893

(**T. transversa* Sowerby). Transverse, biconvex, costate, sulcate, foramen large, deltidial plates disjunct; dorsal interior with thick socket plates to which loop is attached; descending lamellae of loop attached to mediam septum by lateral bars; loop broad. **Tert.–Recent** (Pacific Coast).

***T. transversa** (Sowerby). (**143**—50, 51). **Tert.–Recent.**

DALLINELLA Thomson 1915

(**Terebratella obsoleta* Dall). Like *Terebratalia* internally but with fold on dorsal valve and sulcus on ventral. **Tert.–Recent** (Pacific Coast).

***D. obsoleta** (Dall) (**143**—42, 43). **Recent.**

KINGENA Davidson 1852

(**Terebratula lima* Defrance). Smooth, suboval, lenticular in profile; beak incurved; ventral valve with dental plates; dorsal valve with broad cardinal process and strong median septum; loop with short crural processes, long descending lamellae and broad saddlelike connecting band inclosing median septum. **L. Cret.** (Tex.; Mexico).

K. wacoensis (Roemer) (**143**—32–34). Medium to large in size, pentagonal in outline; front margin truncate; ventral beak strongly incurved; foramen small. **L. Cret.:** Tex.; Mex.

CHAPTER X

PHYLUM MOLLUSCA[1]

The phylum Mollusca includes a great host of familiar animals which are fundamentally alike in organic structure but radically different so far as their shells are concerned. There are over 60,000 known living species and a large number of extinct fossil forms. Modern mollusks live in all kinds of water and may be planktonic, nektonic, or benthonic (both vagrant and sessile). Some snails are even able to live in moist places on land. Fossil mollusks appear to have lived in a similarly broad range of environmental conditions.

The usual classification of Mollusca is based mainly on the nature of the soft parts and to a certain extent on the architecture and structure of the hard parts. Zoölogists have divided the phylum into five classes and paleontologists have referred fossil mollusks to these, even though most fossil forms no longer have living representatives. Certain groups of extinct mollusks have had to be placed under the heading *Incertae sedis* because their taxonomic position is in doubt.

For the sake of convenience, the usual class and ordinal divisions will be considered as follows:

Class **Pelecypoda**
- Order **Prionodesmacea**
  - Section A. **Paleoconcha**
  - Section B. **Taxodonta**
  - Section C. **Schizodonta**
  - Section D. **Isodonta**
  - Section E. **Dysodonta**
- Order **Anomalodesmacea**
- Order **Teleodesmacea**

Class **Gastropoda**

Paleozoic Gastropoda
- Subclass **Protogastropoda**
  - Order **Cynostraca**
  - Order **Cochliostraca**
- Subclass **Eugastropoda**
  - Superorder **Prosobranchia**
    - Order **Archaeogastropoda**
    - Order **Mesogastropoda**
    - Order **Neogastropoda**

Mesozoic to Recent Gastropoda
- Superorder **Prosobranchia**
- Superorder **Opisthobranchia**
  - Order **Tectibranchiata**
  - Order **Pteropoda**
- Superorder **Pulmonata**

Class **Scaphopoda**

Incertae sedis

Class **Amphineura**
- Order **Polyplacophora**
- Order **Aplacophora**

Class **Cephalopoda**
- Subclass **Nautiloidea**
  - Order **Protochoanites**
  - Order **Holochoanites**
  - Order **Mixochoanites**
  - Order **Orthochoanites**
  - Order **Cyrtochoanites**
- Subclass **Ammonoidea**
  - Order **Intrasiphonata**
  - Order **Extrasiphonata**
- Subclass **Coleoidea (Dibranchia)**
  - Order **Belemnoidea**
  - Order **Sepioidea**

The Mollusca have left an extensive fossil record in every geologic period since the beginning of the

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Paleozoic and include many of the best known and most valuable index fossils.

CLASS PELECYPODA (LAMELLIBRANCHIATA)[1,2]

The pelecypods, or lamellibranchs as they are commonly called, are mollusks which have a calcareous bivalved shell and live in all kinds of waters. The valves of the shell are complementary and in most species are of nearly similar size and outline. Each valve has an initial point or *beak*, around which concentric *growth lines* mark successive additions of shell matter. The outer surface of the valves is commonly ornamented concentrically and radially by nodes, ridges, spines, *etc.*

Orientation of most shells is accomplished by holding them with the *hinge line* uppermost and the beaks pointing away from the observer. Thus oriented, the upper border is *dorsal*; the lower *ventral*. The end farthest away from the observer is *anterior* (the mouth is here); that nearest, *posterior*. The valves are designated *right* and *left*.

Length is measured from anterior to posterior border; *height*, from beak or *umbo* to ventral border; and *thickness*, from valve surface to valve surface along a line perpendicular to the plane between the valves.

The valves articulate by means of interlocking *teeth* which are developed on the *hinge* or *cardinal margin* of the valves. These teeth are rather variable in their development and may lie upon a *hinge plate*. Primitive bivalves, and also some specialized types, have the dentition composed of a continuous row of nearly uniform protuberances and *pits* (*sockets*). Such dentition, designated *taxodont*, is well illustrated by *Arca* and *Ctenodonta*. One specialized type of tooth structure consists of a series (three or

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[1] It is a pleasant duty to acknowledge the valuable assistance of the following, who contributed in variable measure to the revision of the Pelecypoda: K. A. Caster, Julia Gardner, Winifred P. Goldring, U. S. Grant IV, R. W. Imlay, Myra Keen, C. H. Kindle, the late E. M. Kindle, N. D. Newell, J. B. Reeside, Jr., P. W. Rhinehart, H. G. Schenck, L. W. Stephenson, and R. B. Stewart.

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less) of short and stout *cardinal teeth*, which start at the beak, and two or less long, slender, *lateral teeth*, not reaching the beak, which lie upon a hinge plate. This dentition, designated *diagenodont*, is illustrated by *Crassatellites*. In the most highly specialized type of dentition, *teleodont*, additional structures are developed: e.g. a roughened area as in *Venus*; accessory lamellae and extra cardinals as in *Mactra*, *etc.* Other types of dentition are: *schizodont*, as developed in *Unio*, with coarse and variable amorphous teeth; *isodont*, in *Spondylus* and partly developed in *Pecten*, consisting of special curving and interlocking teeth derived from the shell below the beak; *cyclodont*, in *Cardium*, with strongly curving teeth from under the beak and no hinge plate; *dysodont*, variable dentition developed from exterior ornamentation; and finally, lack of teeth (*anodont*), as in *Anodonta*. Dentition is very important in subordinal classification as well as in differentiating fossil pelecypods, and every effort should be made to clean well preserved specimens and prepare squeezes of impressions.

The shell is opened by the action of an external elastic *ligament*, which is stretched across the hinge line from valve to valve, or by an internal *cartilage* or *resilium*. An *amphidetic* ligament extends on both sides of the beak (e.g. *Glycimeris*); an *opisthodetic* one lies only behind the beak (e.g. *Venus*). Shells with the former type of ligament often show, under the beaks, a flattened area that consists of a posterior *escutcheon*, which carries the ligament (as in teleodont forms), and an anterior *lunule*. The ligament may be a single elastic strand, designated *alivincular* and developed in *Lima*; a bundle or plate of such strands, designated *multivincular* and illustrated in *Arca*; or a split cylinder in the form of a C-spring, known as *parivincular* and found in *Tellina* and *Venus*. The internal cartilage or resilium may be lodged in *cartilage pits* or *resilifers* (also called *chondrophores*), as in *Mactra*, or supported by variously formed calcareous pieces (*lithodesma*).

The shell is closed by contraction of the *adductor muscles*, which may be single (*monomyarian*) or paired (*dimyarian*), one anterior and the other posterior. Scars marking the place of attachment of the adductor muscles show considerable variation and frequently are preserved in fossil shells.

The *pallial line*, which may be preserved on the inner surface of the valves, marks the line along which the shell-secreting fleshy mantle was attached. If the pelecypod has a retractile siphon, this makes a posterior indentation (*pallial sinus*) in the pallial line.

The primitive nuclear portion of the pelecypod shell is the *prodissoconch*. It is nearly always present but not always recognizable. It usually has the

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general features of a nuculoid shell with taxodont dentition. This primitive dentition may be retained, as in taxodont, or it may be modified later into some more specialized type. This suggests that the prodissoconch of later shells is essentially the adult stage of the earliest ancestral pelecypods.

In their early stages marine pelecypods, like brachiopods, are free-swimming meroplanktonic larvae, which at certain seasons swarm in pelagic areas and thus are widely distributed. Large numbers of pelecypods live in brackish and fresh waters, but on the whole the number of species is relatively small.

Pelecypods are distributed throughout geologic time from the Cambrian, when they seem to have been rare, to the present, when they appear to have reached their acme of development. Many of the most bizarre types, however, evolved and became extinct during the Cretaceous.

The class is here divided into the orders **Prionodesmacea, Anomalodesmacea,** and **Teleodesmacea. Paleoconcha,** the first division of the first order, includes primitive and perhaps degenerate forms and is not a natural group.

Order Prionodesmacea. Siphons absent or imperfectly developed; adductor muscles subequal or with anterior smaller or absent; shell structure nacreous and prismatic, rarely porcelaneous; dorsal area rarely divided into lunule and escutcheon; nepionic stage with taxodont hinge line; permanent dentition taxodont or schizodont; organism not burrowing.

Section A. PALEOCONCHA

SOLEMYA Lamarck 1818

(**S. mediterranea*). Elongate-cylindrical, gaping at each end, with obtuse extremities and very low beaks; ligament internal, posterior, inserted on an oblique process beneath beak; no distinct pallial line. **Dev.–Recent.**

S.? vetusta Meek (**144**—1, 2). **Dev.** (Onondaga–Hamilton): N. Y., Pa., Ohio, Ind., Ky.

PHTHONIA Hall 1869

(**Cypricardites sectifrons* Conrad). Elliptical, with short anterior end; beaks small and appressed; hinge line straight or slightly arched; umbonal slope more or less distinctly defined; surface marked with fine concentric striae, and at times with radiating striae; ligament external; pallial line simple. **Dev.**

***P. sectifrons** (Conrad) (**144**—3). Radii strongest on umbonal ridge and anterior end **Dev.** (Hamilton): N. Y., Md.

CLINOPISTHA Meek and Worthen 1870

(**C. radiata levis*). Moderately convex, with nearly straight basal margin, rounded posterior, and short, subnasute anterior end; callosity present in place of lunule, anterior to beaks; surface marked with fine growth striae; hinge possibly crenulated; ligament external; pallial line simple. **Dev.–Penn.**

C. subnasuta (Hall and Whitfield) (**144**—4). **Dev.** (Hamilton): Ky., Ind.

C. radiata Hall (**144**—5, 6). Radiating markings very weak in var. *levis*. **Penn.:** Ohio to Mo.

PROTHYRIS Meek 1869

(**P. elegans*). Thin-shelled, elongate, with very anterior beaks, and often with nearly parallel cardinal and basal margins; lower anterior end generally notched; surface covered with fine concentric striae; hinge without teeth; ligament external; pallial line simple. **Dev.–Penn.**

P. lanceolata Hall (**144**—8). **Dev.** (Hamilton–Portage): N. Y. to Md., W. Va.

***P. elegans** Meek (**144**—7). Surface marked with an obscure fold and furrow parallel to hinge line. **Penn.:** Ohio and Mich. to Neb.

ORTHONOTA Conrad 1841

(**O. undulata* Conrad). Extremely elongate, with very anterior beaks; cardinal and basal margins straight and parallel; umbonal slope defined by one or more distinct folds which extend from beak to posterior basal margin; surface concentrically striated; hinge without teeth; pallial line simple. **Sil., Dev.**

***O. undulata** Conrad (**144**—9, 10). **Dev.** (Hamilton, Ithaca): N. Y. to Md. and W. Va.

ORTHODESMA Hall and Whitfield 1875

(**O. rectum*). Transversely elongate, somewhat higher posteriorly than anteriorly; valves thin, gaping at each end, usually marked by an umbonal ridge, anterior to which is a broad depression; surface bearing distinct concentric striae; hinge plate without teeth, thin and long; ligament mostly external; pallial line simple. **Ord.**

O. subnasutum (Meek and Worthen) (**144**—14, 15). **Ord.** (Galena): Ill., Minn.

***O. rectum** H and W (**144**—11). **U. Ord.** (Waynesville): Ohio, Ind.

O. canaliculatum Ulrich (**144**—12, 13). Differs from other species in the strong, channel-like depression of hinge line, nearly parallel cardinal and basal margins, rounded posterior margin, and in peculiar pallial line which consists (on internal fillings) of a straight row of obscure pustules extending backward from base of anterior adductor scar. **U. Ord.** (Richmond): Que.; Ohio, Ind., Minn.

CUNEAMYA Hall and Whitfield 1875

(**C. miamiensis*). Differs from *Grammysia* in having a weak hinge plate which lacks cardinal folds; a shallow median furrow usually present. **Ord., Sil.**

***C. miamiensis** H and W (**144**—16, 17). **U. Ord.** (Richmond): Ohio, Ind. (Waynesville).

GRAMMYSIA Verneuil 1847

(**Pterinea bisulcata* Conrad). Beaks prominent and incurved, anterior to middle; escutcheon and lunule well defined; valves traversed from beak to base by an oblique sinus or depression and adjacent fold;

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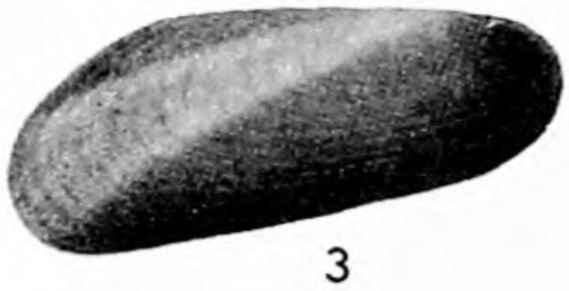

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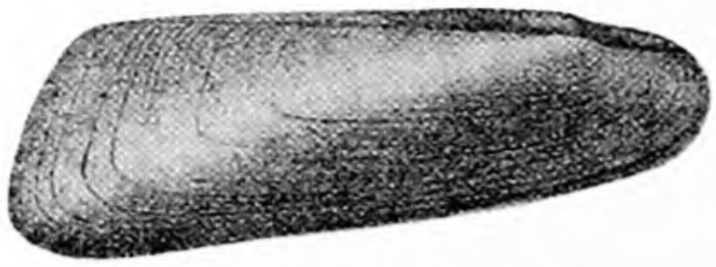

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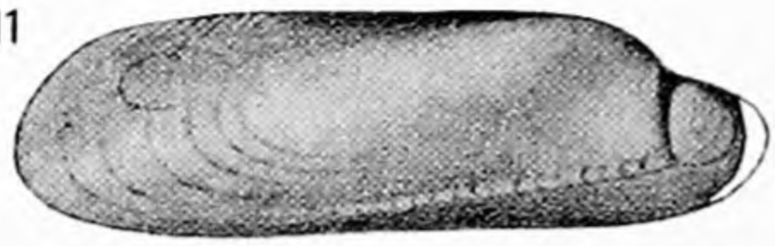

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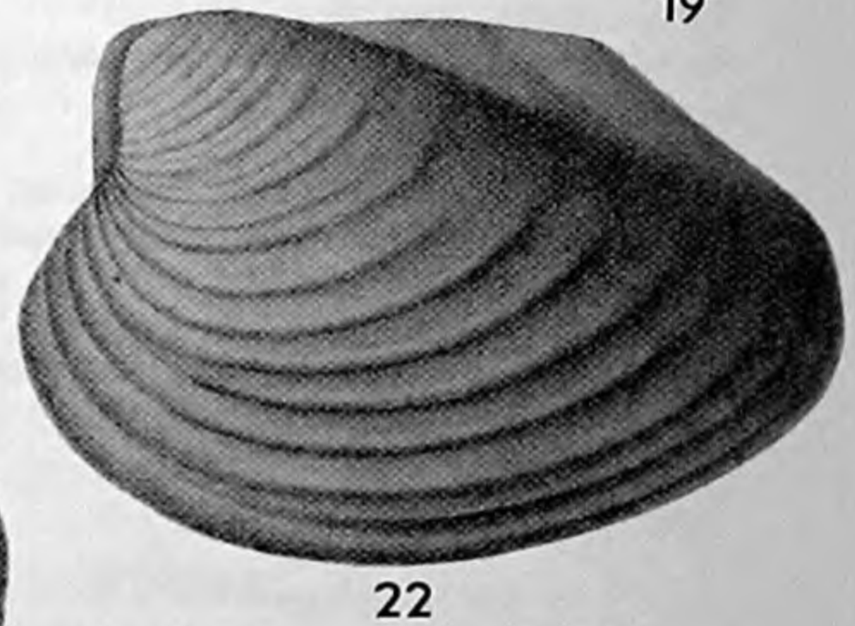

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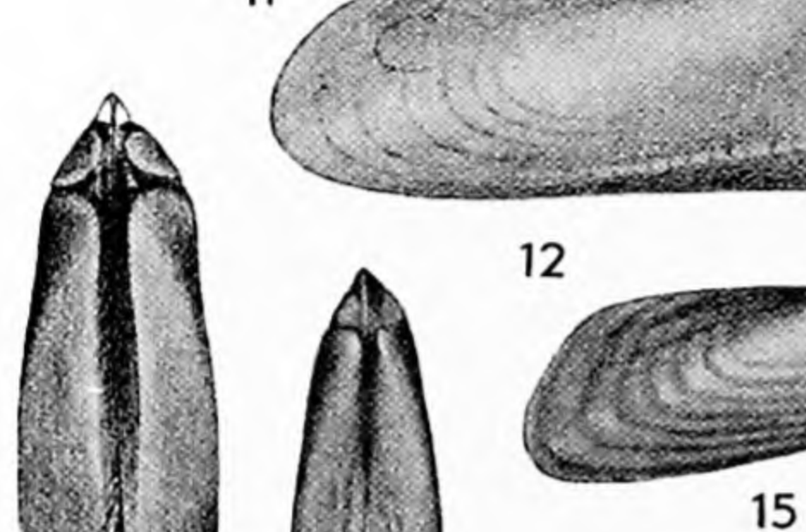

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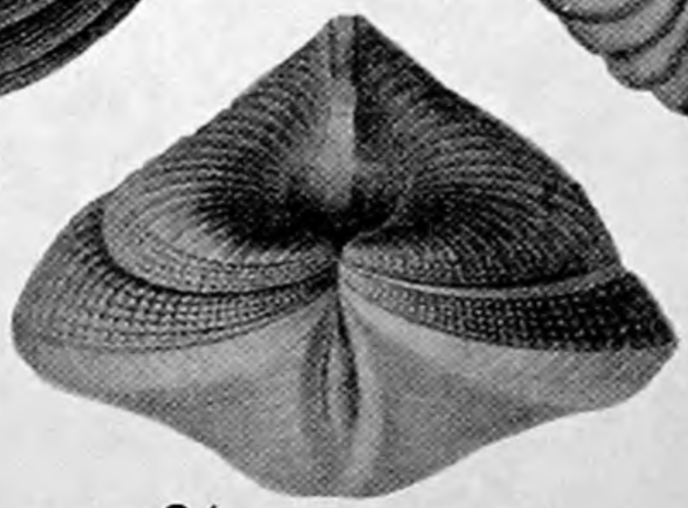

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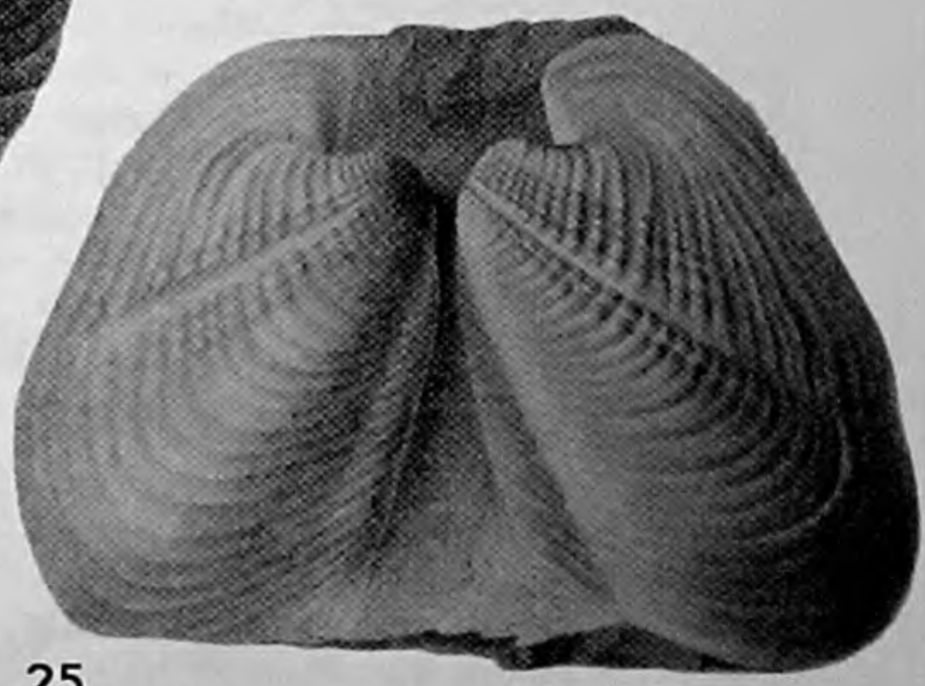

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which may be duplicate and which alternate in the two valves; surface marked by concentric growth lines and undulations; hinge plate short and strong, with one or two cardinal folds typically (144—20); ligament external; pallial line simple. **Sil.–Miss.**

***G. bisulcata** (Conrad) (144—20). **Dev.** (Hamilton–Naples): N. Y. to Md.

G. nodocostata Hall (144—24, 25). **Dev.** (Onondaga–Hamilton): Ont.; N. Y., Mich., Ohio, Wis.

G. arcuata (Conrad) (144—26, 27). Distinguished by its somewhat elongate form, rounded posterior extremity, flattened or constricted base, and by extension of concentric folds across whole length of shell. **Dev.** (Hamilton): Ont.; N. Y., Pa., Md., Ohio, Ind. (Onondaga and L. Portage also).

G. communis Hall (144—23). Umbonal slope subangular. **U. Dev.:** N. Y. to Md., Ohio.

G. hannibalensis (Shumard) (144—18, 19). Similar to preceding but higher proportionally, with a more broadly rounded umbonal slope. **L. Miss.:** Ohio to Mo.

GRAMMYSIOIDEA Williams and Breger 1916

(**G. princiana*). Differs from *Grammysia* in absence of radial fold and sinus. **Dev.**

G. alveata (Conrad) (144—21, 22). **Dev.** (Hamilton): N. Y., Pa., Va.

GLOSSITES Hall 1885

(**G. lingualis*). Elliptical, with short anterior and large rounded posterior extremity; beaks small and appressed; hinge line long and gently arcuate; umbonal slope prominent only above; surface marked by concentric striae which often become lamellose; lunule distinct; teeth doubtful; ligament external; muscular impressions shallow; distinguished from *Modiomorpha* by its outline and presence of lunule. **Dev.**

***G. lingualis** Hall (144—28). **U. Dev.** (Chemung): N. Y., Pa., Colo. (Ouray).

SAFFORDIA Ulrich 1894

(**S. ventralis*). Small, transversely ovate, equivalved, and very inequilateral, with beaks near anterior extremity; surface with moderate umbonal ridge and a depression dorsally; lunule and escutcheon present; one wedge-shaped cardinal tooth and a posterior lateral tooth present in left valve and corresponding cavities in the right; resilifer present; pallial line simple; differs from *Grammysia* in the teeth and in greater depth of anterior muscle scar. **Ord.**

S. modesta Ulrich (144—31, 32). **Ord.** (Galena): Baffin Land; Wis., Minn.

***S. ventralis** Ulrich (144—33, 34). **U. Ord.** (Maquoketa): Wis., Minn.

PALAEANATINA Hall 1870

(**P. typa*). Left valve larger than right; elliptical, with short anterior and longer posterior end; beaks low, that of left valve rising above that of right; umbonal slope prominent; valves crossed from beak to base by a shallow depression, both umbonal ridge and depression less prominent in right valve; surface concentrically striated; hinge with two slender processes beneath beak; pallial line simple. **Dev.**

***P. typa** Hall (144—29). **U. Dev.** (Conewango): N. Y., Pa.

PRORHYNCHUS Hall 1885

(**Palaeanatina quadrata*). Left valve large and more gibbous; anterior end of valves truncate; beaks low; cardinal line straight; surface with concentric growth lines; hinge line with a strong lateral tooth or fold. **Dev.**

P. angulatum Hall (144—30). **U. Dev.** (Conewango): Pa.

TELLINOPSIS Hall 1869

(**Nuculites subemarginata* Conrad). Elliptical, with rounded anterior and truncate or notched posterior end; beaks small, subcentral; umbonal slope prominent; surface concentrically and weakly radially striated; hinge without teeth; ligament external; muscle impressions shallow. **Dev.**

***T. subemarginata** (Conrad) (145—11). From beak a flattening or depression extends to both anterior and posterior margins. **Dev.** (Hamilton): N. Y. to Md., W. Va.

CARDIOPSIS Meek and Worthen 1861

(**C. radiata*). Valves gibbous, inequilateral, subcircular, with short hinge line and prominent incurved beak; surface marked by radiating striae or costae and with concentric growth lines; hinge with one or two cardinal teeth. **Miss., Penn.**

***C. radiata** M and W (145—10). **Miss.** (Kinderhook): Ind., Ill.

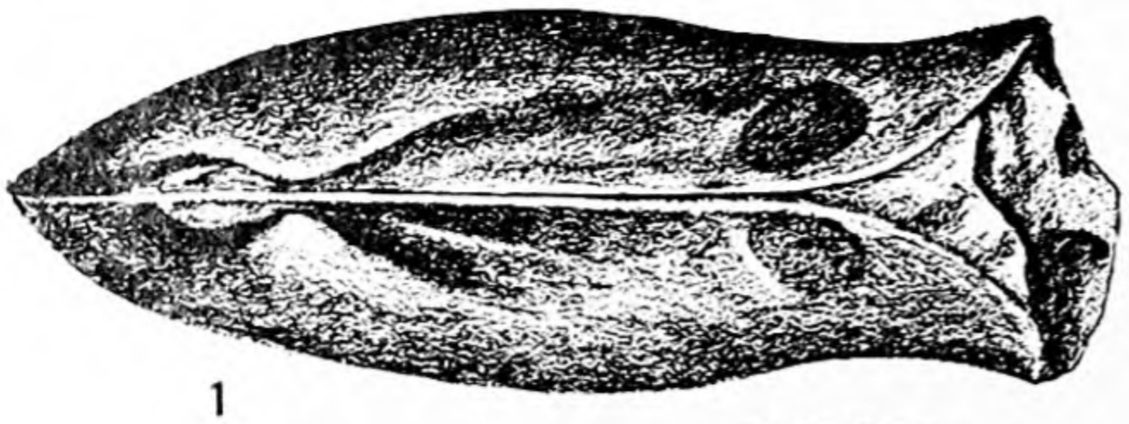
PSILOCONCHA Ulrich 1893

(**P. grandis*). Shell very thin, elongate, gaping

PLATE 144

[Figures are x1 and after Hall [Pal N Y 5] unless otherwise indicated.]

1, 2. Solemya vetusta. Dorsal view; right valve. **3. Phthonia sectifrons** [Md G S, M Dev]. Large right valve. **4–6. Clinopistha** spp. **4. C. subnasuta.** Right valve. **5, 6. C. radiata** [Ind G S 13]. Left valve and dorsal view. **7, 8. Prothyris** spp. **7. P. elegans** [USGS Neb 1872 (Hayden)]. Right valve (x1.3). **8. P. lanceolata.** Right valve (x2). **9, 10. Orthonota undulata.** Left valve and specimen showing both valves. **11–15. Orthodesma** spp. **11. O. rectum** [Pal Ohio 2]. Right side. **12, 13. O. canaliculatum** [Minn G S 3 (2)]. Filling showing impression of right interior and dorsum. **14, 15. O. subnasutum** [Minn G S 3 (2)]. Filling showing impression of right interior and dorsum. **16, 17. Cuneamya miamiensis** [Pal Ohio 2]. Right valve and cardinal view of type. **18–20. Grammysia** spp. **18, 19. G. hannibalensis** [Mo G S, Bien Rp 1929–1930]. Left valve and anterior view. **20. G. bisulcata.** Right valve. **21, 22. Grammysioidea alveata.** Anterior and left side views. **23–27. Grammysia** spp. **23. G. communis.** Right valve. **24, 25. G. nodocostata.** Cardinal view and specimen with both valves. **26, 27. G. arcuata.** Right and left valves. **28. Glossites lingualis.** Left valve. **29. Palaeanatina typa.** Left valve. **30. Prorhynchus angulatum.** Large right valve. **31–34. Saffordia** spp. [Minn G S 3 (2)]. **31, 32. S. modesta.** Left side and front views of a filling. **33, 34. S. ventralis.** Hinge of right valve; left exterior.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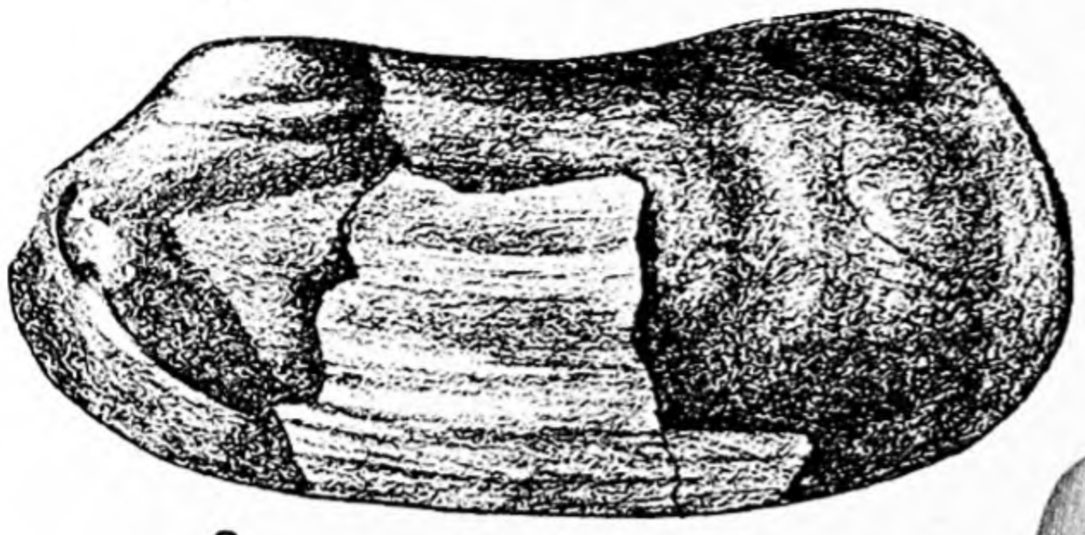
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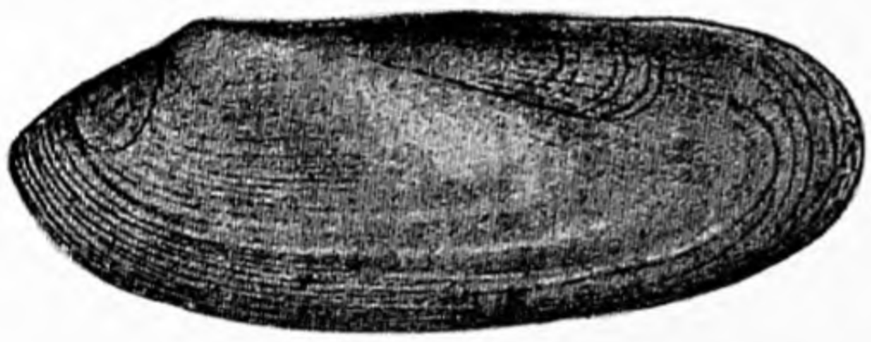
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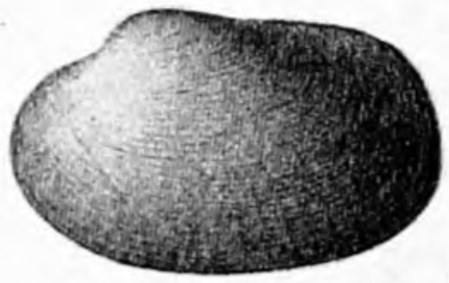
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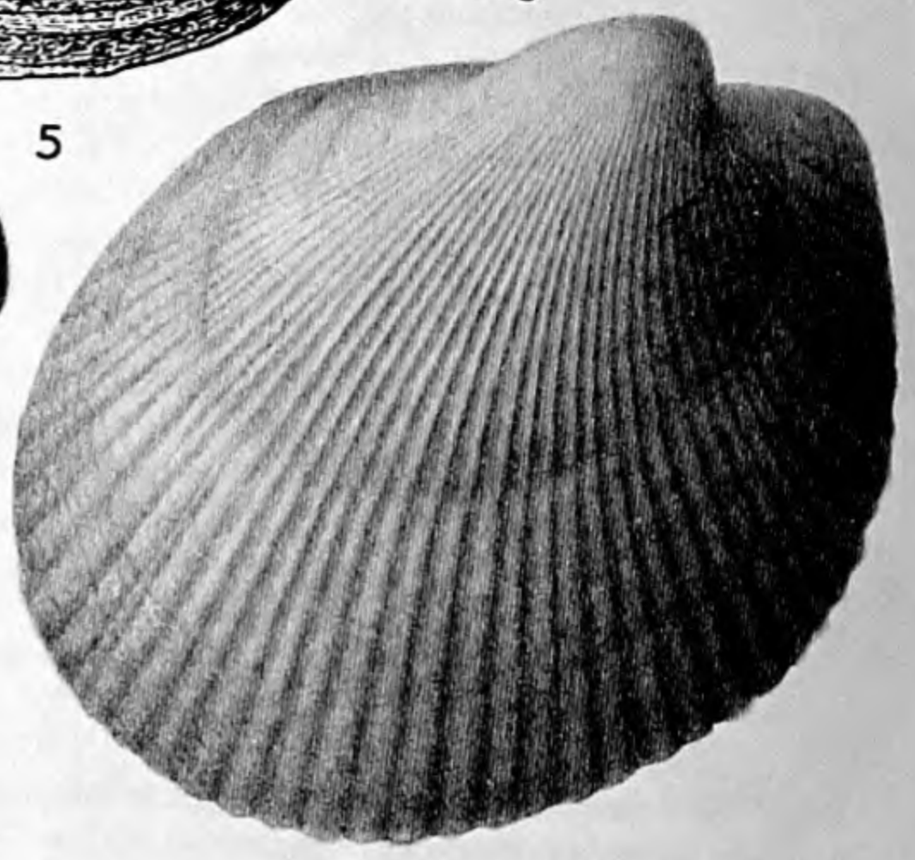
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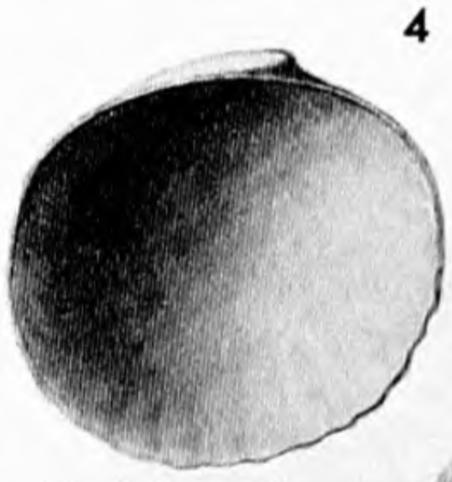
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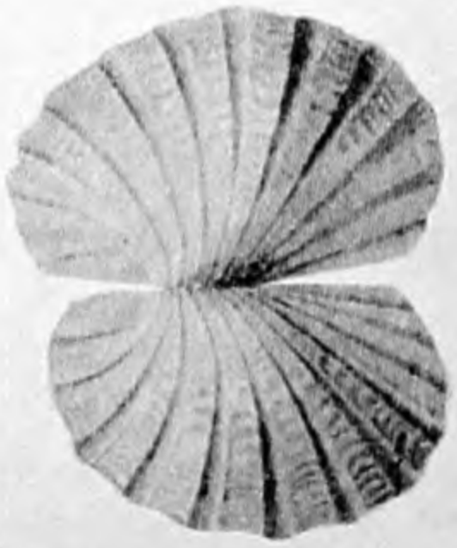
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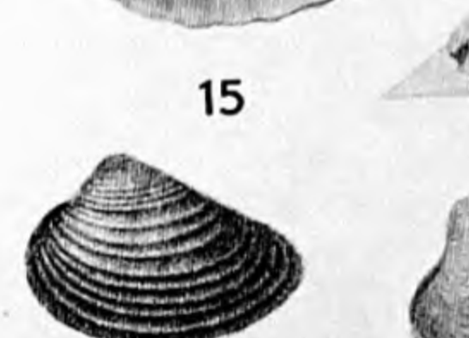
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slightly at both ends; hinge plate very narrow, without teeth; ligament internal, linear; muscle impressions very shallow, the posterior three times as long as anterior; pallial line simple. **Ord.**

***P. grandis** Ulrich (**145**—3, 4). **U. Ord.** (Waynesville): Ohio.

CHAENOMYA Meek 1864

(**C. leavenworthensis* Meek and Hayden). Thin, longitudinally oblong or subcylindrical; anterior side rounded, closed, posterior long, truncated, and gaping; surface marked with radiating granules and concentric growth lines; cardinal margin inflected; teeth absent; ligament external; scars of anterior adductors and pedal muscles connected; pallial line with broad, shallow sinus. **Penn., Perm.**

***C. leavenworthensis** M and H (**145**—1, 2). Concentric undulations curve up abruptly behind, parallel to truncated posterior margin. **Penn.:** Mississippi Valley, Colo., Tex.; **Perm.:** Kan.

EDMONDIA Koninck 1841

(**Isocardia unioniformis* Phillips). Oval, inflated, gaping anteriorly, and with a narrow ridge behind the beaks; beaks ranging from subcentral to nearly anterior; surface concentrically striated; hinge line thin, arched, lacking teeth; ligament external, resting in a groove along hinge line; pallial line simple. **Dev.–Perm.**

E. philipi Hall (**145**—8). **U. Dev.** (Chemung–Conneaut): N. Y., Pa., Mont.

E. subovata Hall (**145**—7). **U. Dev.** (Naples–Conneaut): N. Y., Pa.; **Dev.** or **Miss.:** Ohio (Bedford).

E. aspinwallensis Meek (**145**—5, 6). **Penn.:** W. Va. to Neb. and Mo.

PANENKA Barrande 1881

(**P. bohemica*). Equivalved, length and height nearly equal; beaks prominent and incurved; shell thin, marked by growth lines and usually by strong radial ridges. **Sil., Dev.**

P. dichotoma Hall (**145**—9). **Dev.** (Schoharie–Onondaga): N. Y. to Md., W. Va.

ONTARIA Clarke 1904

(**Ungulina suborbicularia* Hall). Equivalve, exceedingly thin; beaks not prominent, turned posteriorly; cardinal area beneath beak nearly obsolete; surface concentrically and radially striated. **Dev.**

***O. suborbicularis** (Hall) (**145**—12–14). **Dev.** (Naples): N. Y., Va.

PARACARDIUM Barrande 1881

(**P. delicatum*). Small, circular; beaks high and slightly projecting; surface with fine, simple, radial ribs; hinge at times with row of minute, toothlike projections. **Sil., Dev.**

P. doris Hall (**145**—15, 16). **U. Dev.** (Genesee–Chemung): N. Y. to Md., W. Va.

BUCHIOLA Barrande 1881

(**B. retrostriata* Buch). Cardinal line long and straight; beaks pointing forward; a row of minute, toothlike projections often present on outer edge of the narrow cardinal area; surface marked by a few broad plications crossed by fine lines curved prominently upward as they cross the ribs. **Sil., Dev.**

B. speciosa (Hall) (cf. **B. retrostriata** Buch) (**145**—17, 18). **U. Dev.** (Tully–Genesee and equivalents): N. Y. to Va.; Alta., U. Mackenzie Valley.

PARARCA Hall 1885

(**P. venusta*). Cardinal line straight; valves regularly convex below, gibbous above; surface with numerous fine radii. **Dev.**

P. erecta Hall (**145**—19, 20). **U. Dev.** (Conewango): Pa.

Section B TAXODONTA
Superfamily NUCULACEA
CTENODONTA Salter 1851

(**Tellinomya nasuta* Hall). Equivalve, surface smooth or with concentric growth lines; hinge arcuate, with series of curved, transverse teeth interrupted at times beneath the beak; cardinal area not striated; ligament small, immediately behind beaks; adductor muscle impressions nearly equal; pallial line simple; differs from *Nucula* in lacking resilifer beneath beak, and lunule and escutcheon. **Ord., Sil.** (widespread throughout N. America).

C. gibberula Salter (**146**—1, 2). **Ord.** (Stones River): Tenn.; **Black River:** Ont.; N. Y., Pa., Tenn., Wis., Ill., Minn., Ia.

***C. nasuta** (Hall) (**146**—5). **Ord.** (Black River

PLATE 145

[Figures are x1 and after Hall [Pal N Y 5] unless otherwise indicated.]

1, 2. Chaenomya leavenworthensis [Kan G S 6; after Meek]. Dorsal and left side views. **3, 4. Psiloconcha grandis** [Minn G S 3]. Dorsal and left side views of a filling. **5–8. Edmondia spp. 5, 6. E. aspinwallensis** [Ind G S 13]. Right side and dorsal views. **7. E. subovata.** Left valve. **8. E. philipi.** Left valve. **9. Panenka dichotoma.** A large right valve. **10. Cardiopsis radiata.** Right valve. **11. Tellinopsis subemarginata.** Right valve. **12–14. Ontaria suborbicularis** [N Y St Mus, M 6]. Right valve (x1.5); interior and cardinal views (x5). **15, 16. Paracardium doris** [N Y St Mus, M 6]. Left interior (x10) and exterior (x3). **17, 18. Buchiola speciosa** [N Y St Mus, M 6]. Umbonal view of right valve (x5); valves in conjunction (x6). **19, 20. Pararca erecta.** Hinge of right valve showing minute crenulations; left valve. **21–38. Nucula spp. 21. N. (Nuculoidea) lirata.** Right valve. **22. N. (Nuculoidea) opima.** Right valve. **23. N. bellistriata.** Large right valve. **24. N. corbuliformis.** Large right valve. **25. N. beyrichi** [Kan G S 6; after Meek]. Right valve. **26, 27. N. (Nuculopsis) girtyi** [Mus Roy HN Belgique, B 10]. Dorsal view and right valve (x2). **28, 29. N. slackiana** [Md G S, U Cret]. Left exterior and dorsal view. **30, 31. N. (Nuculopsis) croneisi** [JP 13]. Neotype of "*Nucula parva*" McChesney (x3), dorsal view and right valve. **32, 33. N. montpelierensis** [USGS, B 436]. Cardinal view and left valve of type (x3). **34. N. (Pectinucula) cancellata** [USGS Ter 9]. Right valve of type (x2). **35. N. planimarginata** [USGS, PP 128]. Left valve (x2). **36. N. ovula** [Md G S , Eoc]. Right exterior (x3). **37, 38. N. percrassa** [USGS, PP 137]. Left valves, interior and exterior.

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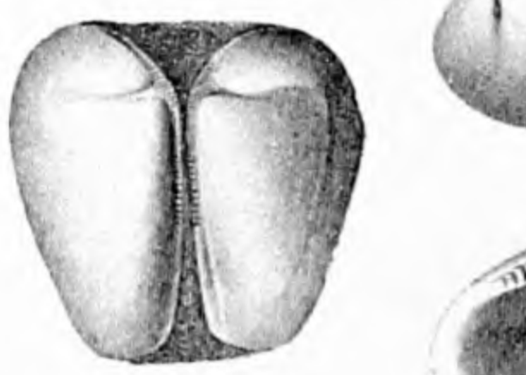
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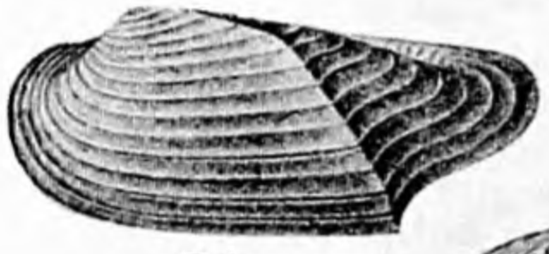
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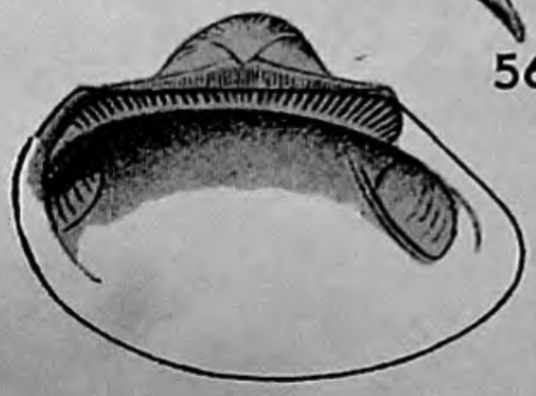
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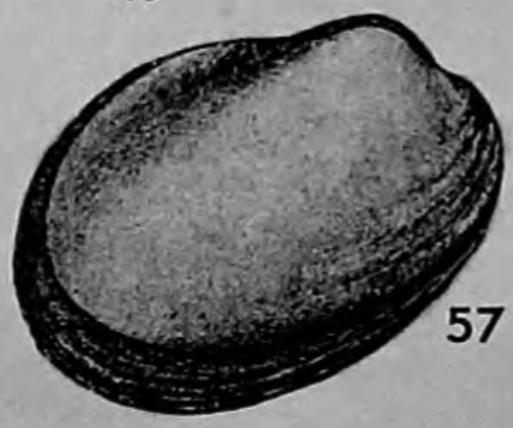
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and equivalents): Ont.; N. Y., N. J., Ind., Wis., Ill., Minn., Mo. (also occurs in Trenton).

C. socialis Ulrich (**146**—6, 7). Quite inequilateral, with moderate convexity. **Ord.:** Minn. (Black River), Ky. (Trenton).

C. obliqua (Hall) (**146**—3, 4). Shell 1 to 5 mm wide; hinge plate bent nearly perpendicularly. **Ord.** (Trenton–Richmond): Ohio, Ind., Ky., Tenn., Ill., Ia.

C. fecunda (Hall) (**146**—8, 9). Hinge plate arcuate, muscle scars faint. **U. Ord.** (Maquoketa): Wis., Ill., Minn., Ia.

NUCULA Lamarck 1799

(**Arca nucleus* Linnaeus). Pearly, small, equivalve, ranging in outline from trigonal to nearly circular or transversely elliptical; beaks often subcentral, usually posterior to middle and turned backward; surface concentrically at times radially striate, or even radially ribbed (*Pectinucula*); hinge with triangular resilifer beneath beaks and a series of small transverse teeth on each side; two subequal adductor muscle impressions in each valve; pallial line simple; interior margins often crenulate; possibly a polyphyletic group; NUCULOIDEA Williams and Breger 1916 (**Cucullea opima* Hall) is applied to Paleozoic Nuculids with a smooth ventral margin; NUCULOPSIS Girty 1911 (**N. girtyi* Schenck) is applied to Paleozoic Nuculids with a trigonal outline and a smooth ventral margin. **Sil.–Recent.**

N. (Nuculoidea) lirata (Conrad) (**145**—21). **Dev.** (Hamilton–Tully): Ont.; N. Y. to Md.

N. (*Nuculoidea) opima (Hall) (= **N. randalli** Hall) (**145**—22). Differs from *N. lirata* in having beaks broader and more closely incurved and in absence of strong, concentric undulations. **Dev.** (Hamilton): N. Y. to W. Va. Chemung?

N. bellistriata (Conrad) (**145**—23). **Dev.:** Hamilton of N. Y. to Md., W. Va.; Portage of Pa.

N. corbuliformis Hall (**145**—24). **Dev.** (Hamilton–Chemung): N. Y. to Md., W. Va.

N. (*Nuculopsis) girtyi Schenck (= **N. ventricosa** Hall) (**145**—26, 27). **M. Penn.:** W. Va. to Colo. to Tex.

N. (Nuculopsis) croneisi Schenck (**145**—30, 31). **Penn.:** Ohio to Ia. to Tex.

N. beyrichi Schauroth (**145**—25). Hinge line nearly rectangular at beaks. **Penn.:** Ill., Ia., Neb., Kan.

N. montpelierensis Girty (**145**—32, 33). **Perm.** (Phosphoria): Wyo., Idaho.

N. planimarginata Meek and Worthen (**145**—35). **U. Cret.** (Fox Hills): N. and S. Dak., Mont., Wyo., Colo. Lance of N. and S. Dak.; Pierre of N. Mex.

N. slackiana Gabb (**145**—28, 29). Like *N. percrassa* but differing in having less prominent umbos, a more broadly rounded ventral margin, and in being less contracted posteriorly. **U. Cret.:** N. J. and Del. (Matawan), Del. and Md. (Monmouth), N. J. (Magothy).

N. (Pectinucula) cancellata Meek and Hayden (**145**—34). **U. Cret.** (Montanan): Plains and Rocky Mountain regions of N. America; Mex.

N. percrassa Conrad (**145**—37, 38). **U. Cret.:** Ripley and Owl Creek of Tenn. and Miss.; Ripley and Providence of Ga. and Ala.

N. ovula Lea (**145**—36). **Eoc.:** Atlantic and Gulf Coastal Plain.

ACILA H. and A. Adams 1858

(**Nucula divaricata* Hinds). Shell nuculid, with posterior ventral margin of valves produced into a short rostrum and set off from rest of shell by shallow sinus extending from near umbos to ventral margin; surface sculpture of fine radial plications bifurcating along a lateral axis, sometimes with more than one axis of bifurcation. **L. Cret.–Recent** (distribution of fossil forms worldwide; today confined to Indo-Pacific).

A. (Truncacila) decisa (Conrad) (**146**—11). Shell outline truncate-ovate. **Eoc.:** Wash. to S. Cal.; also in **Paleoc.** (Martinez) of Cal.

A. (Truncacila) shumardi (Dall) (**146**—10.) Ven-

PLATE 146

[Figures are x1 and after Hall [Pal N Y 5] unless otherwise indicated.]

1–9. Ctenodonta spp [Minn G S 3 (2), except 3]. **1, 2. C. gibberula.** Left valve and large right exterior. **3, 4. C. obliqua.** Small form (x12) [Tenn G S, B 38]; and cardinal view of a filling (x5). **5. C. nasuta.** Small left valve. **6, 7. C. socialis.** Outline views of three specimens; and hinge line of two right valves (x3). **8, 9. C. fecunda.** Right valve and cardinal view. **10–12. Acila spp.** [GSA, SP 4]. **10. A. shumardi.** Right valve (x1.6). **11. A. decisa.** Right valve (x3). **12. A. gettysburgensis.** Left valve (x1.5). **13–16. Nuculites spp. 13, 14. N. oblongatus.** Filling of both valves and of left one. **15, 16. N. triqueter.** Right and conjoined valves. **17–19. Cleidophorus spp. 17. C. planulatus.** [Pal N Y 1]. Left valve. **18, 19. C. neglectus** [Minn G S 3 (2)]. Right valves, interior and exterior. **20–25. Palaeoneilo spp. 20, 21. P. constricta.** Left interior (x2) and right valve. **22. P. muta.** Left valve. **23. P. fecunda.** Right valve. **24. P. emarginata.** Left valve. **25. P. sulcatina.** Left valve. **26–35. Nuculana spp. 26, 27. N. acuta** [USGS, PP 142]. Right exterior and interior. **28. N. (Sacella) parva** [Md G S, Eoc]. Right valve (x7). **29. N. rostellata.** Left valve (x2). **30, 31. N. bellistriata** [Ind G S 13]. Left valve and cardinal view (x1.2). **32. N. (Sacella) gabbi** [Ac N Sc Phila, SP 3]. Left valve of lectotype (x3). **33. N. astoriana** [San Diego Soc N H, M 1]. Right valve. **34. N. diversa.** Left valve (x2). **35. N. washingtonensis** [U Wash Pub G 1]. Right valve of genotype. **36–42. Yoldia spp. 36. Y. eborea** [B Am Pal 4]. Left valve. **37. Y. strigata** [USGS, PP 59]. Right valve of type. **38, 39. Y.? longifrons** [Pal N J 1]. Enlargement of hinge and left valve. **40, 41. Y. evansi** [USGS Ter 9]. Left valve; filling showing sinus and hinge teeth. **42. Y. scitula** [USGS, PP 128]. Left valve of type (x2). **43–47. Parallelodon spp. 43. P. obsoletus** [Kan G S 6]. Right valve. **44. P. hamiltoniae** [Pal N Y 1]. Right valve. **45. P. tenuistriatus** [USGS Neb 1872 (Hayden)]. Right valve. **46. P. chemungensis.** Left valve. **47. P. (Nanonavis) brewerianus** [GSA, SP 16]. Left valve of type (x1.6). **48–51. Nemodon spp. 48. N. sulcatinus** [USGS Ter 9]. Left valve (x3). **49. N. eufaulensis** [Md G S, U Cret]. Left valve (x3). **50, 51. N. brevifrons** [NCGS 5]. Hinge (x1.5) and left valve of type. **52–55. Breviarca spp. 52, 53. B. exigua** [USGS Ter 9]. Left valve of type (x3) and anterior view of same. **54, 55. B. haddonfieldensis** [Pal N J 1]. Right valve and right interior (x2). **56–60. Cyrtodonta spp.** [Minn G S 3 (2)]. **56, 57. C. huronensis.** Hinge and right valve. **58, 59. C. billingsi.** Dorsal view and right side of a filling. **60. C. grandis.** Right valve (x0.5).

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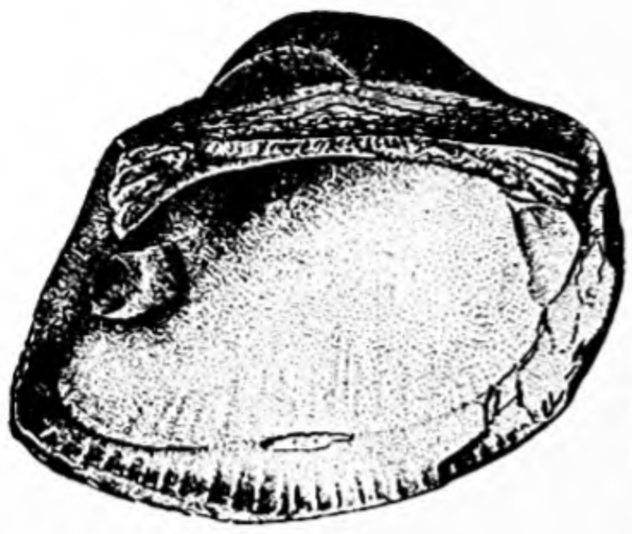

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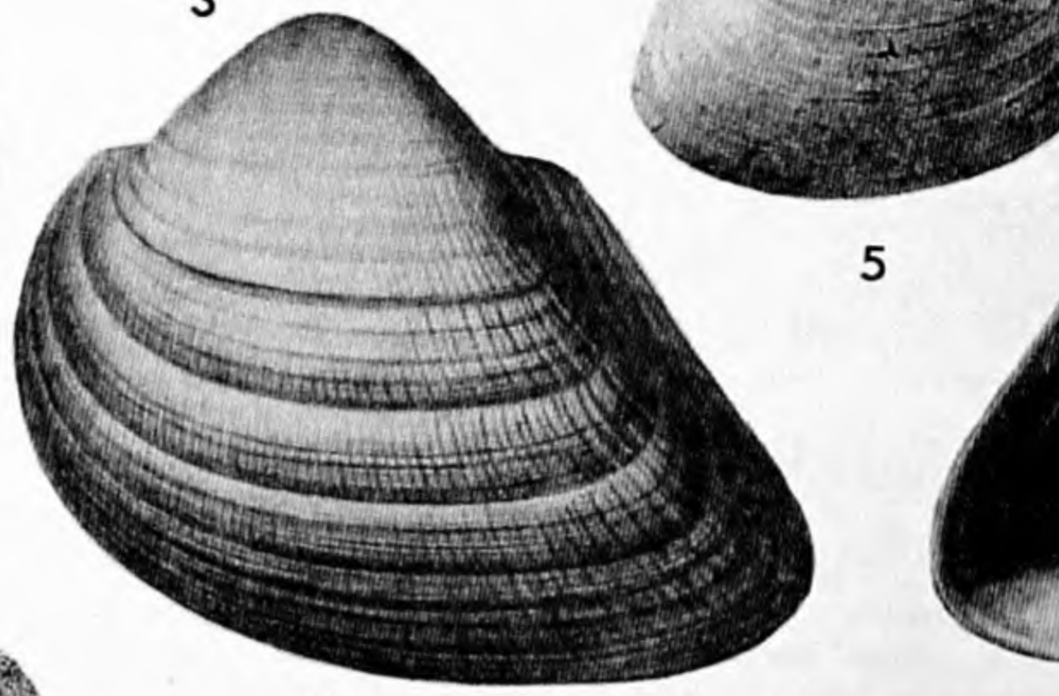

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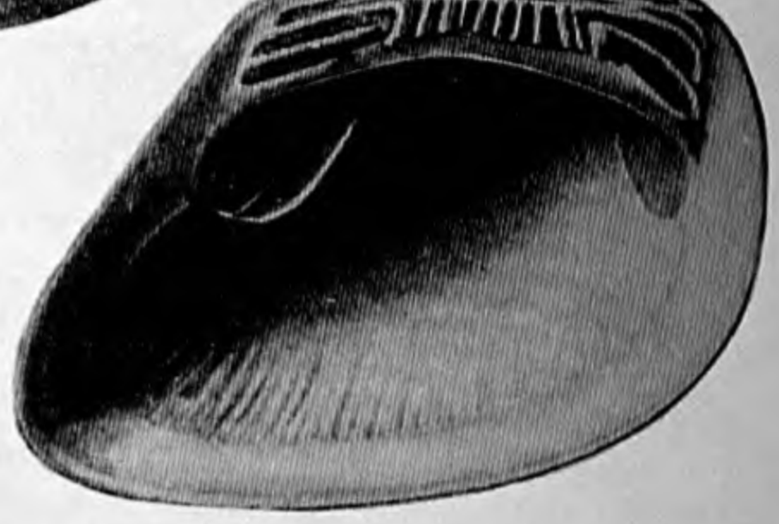

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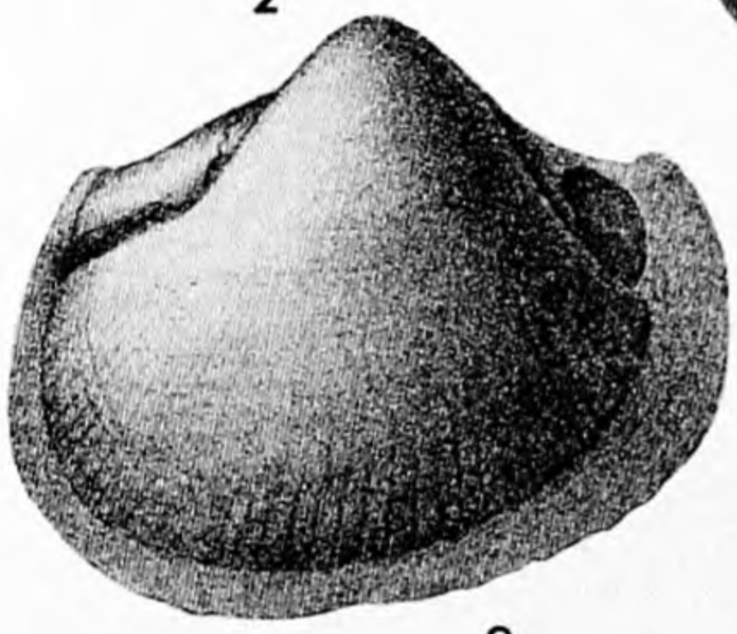

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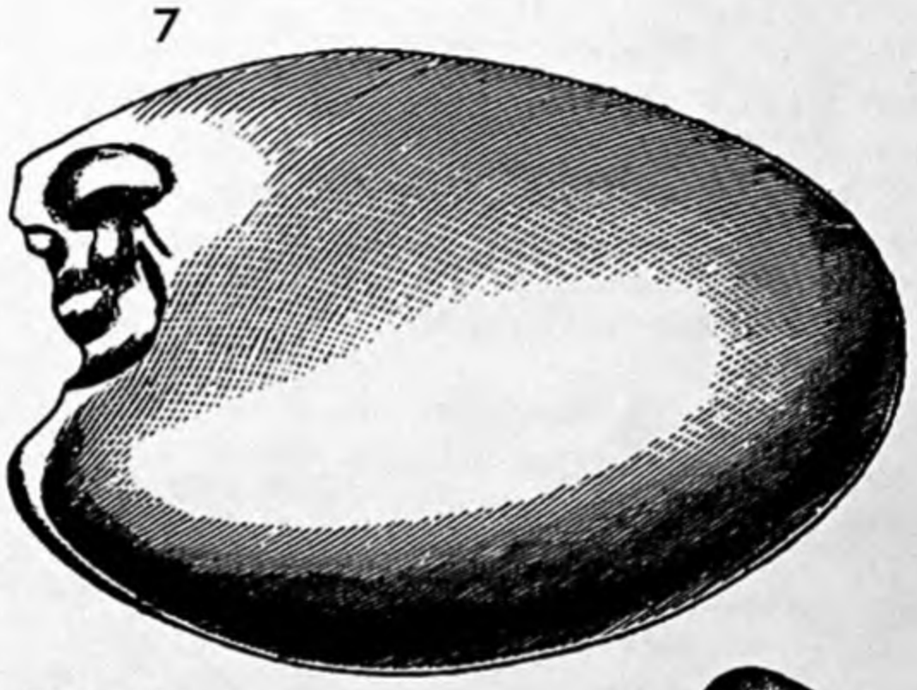

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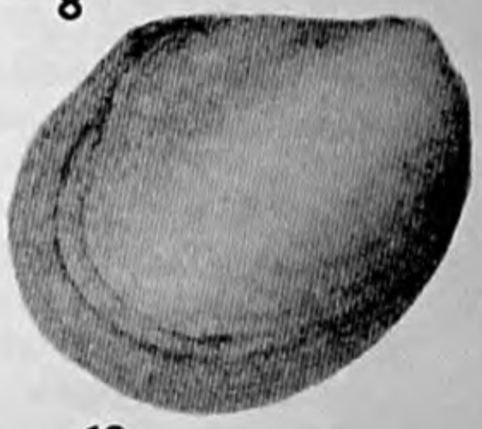

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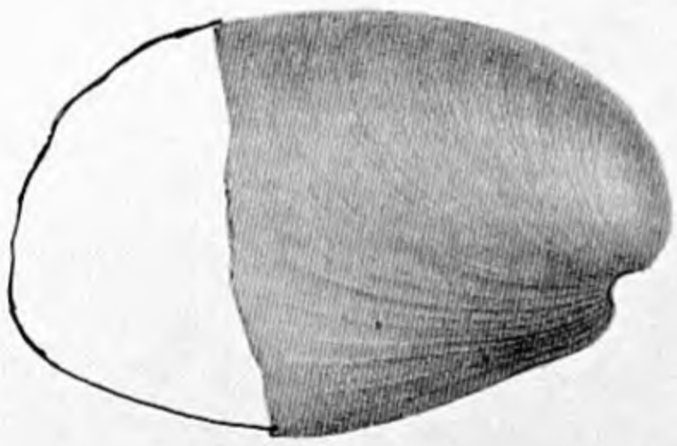

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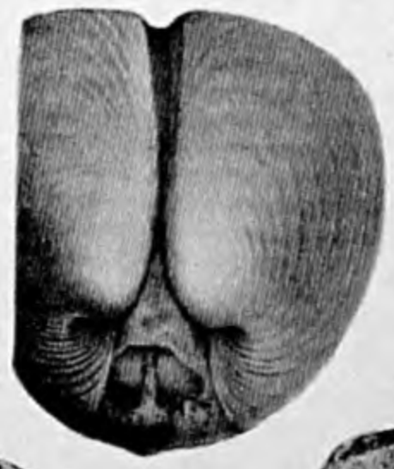

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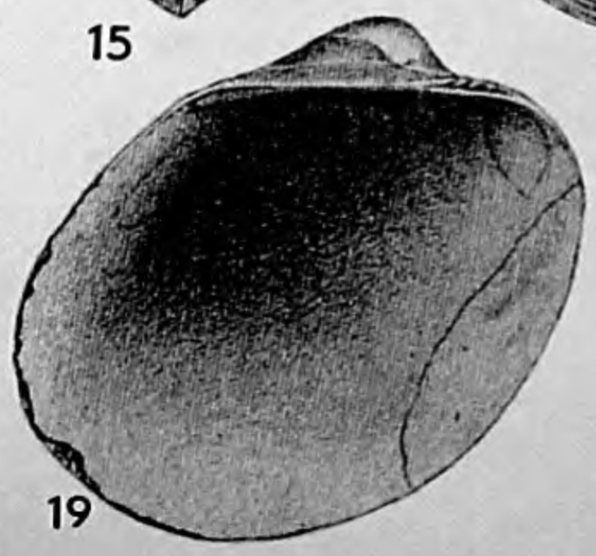

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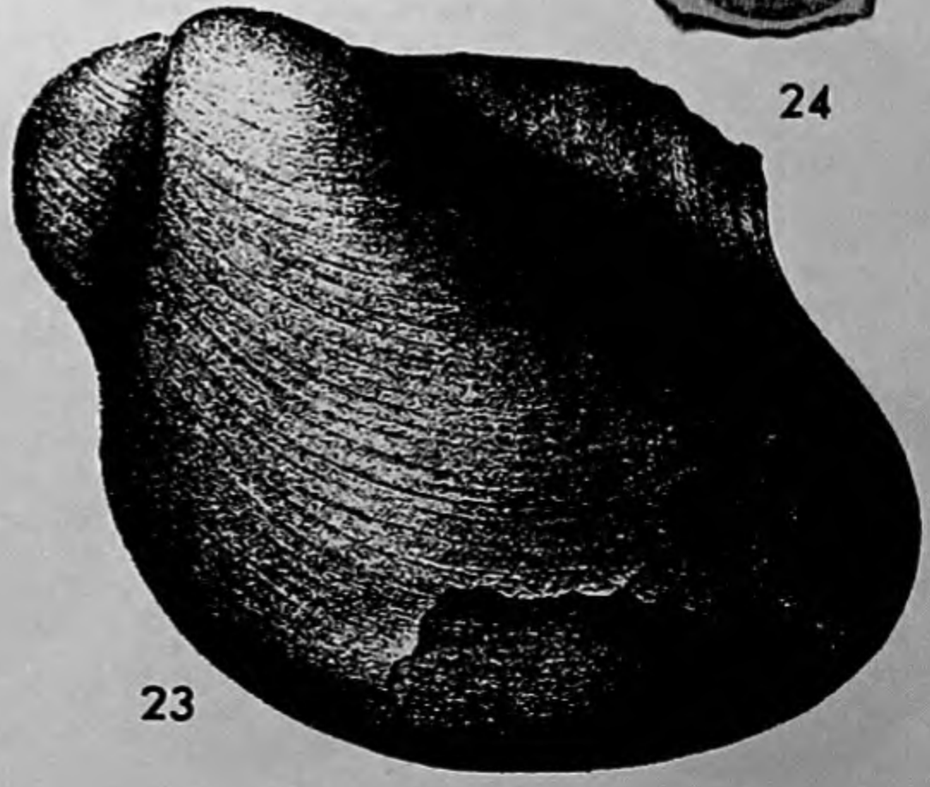

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tral margin gently rounded, posterior end abruptly truncated. **Olig.:** Wash to Cal.

A. (Acila) gettysburgensis Reagan (**146**—12). Shell inflated and distinctly rostrate. **U. Olig., L. Mioc.:** Wash., Cal.

NUCULITES Conrad 1841

(**N. oblongatus*). Differs from *Nucula* in lacking resilifer beneath beak, and in having a nearly or quite vertical partition internally, separating anterior muscle scar from cavity of shell and extending about two-thirds distance from beak to base; this partition leaves a deep furrow on internal impressions or fillings, the form in which the fossils usually occur. **Ord.–Dev.**

***N. oblongatus** Conrad (**146**—13, 14). **Dev.** (Marcellus–Hamilton): Me., N. Y. to Va., W. Va., Ohio. Also persists into Portage and Chemung.

N. triqueter Conrad (**146**—15, 16). **Dev.** (Hamilton–Genesee): Que., Ont.; N. Y. to Va., W. Va., Ohio. Most characteristic of Hamilton.

CLEIDOPHORUS Hall 1847

(**Nuculites planulata* Conrad). Differs from *Nuculites* in lacking teeth at hinge line except in extreme posterior position. **Ord.–Dev.**

***C. planulatus** (Conrad) (**146**—17). Characterized by prominent umbonal ridge extending from beak to posterior extremity, and by conspicuous flattening of shell hingeward from this ridge. **U. Ord,** (Eden and Maysville): Ont.; N. Y. to Md., Ohio.

C. neglectus Hall (**146**—18, 19). **U. Ord.** (Maquoketa): Wis., Ill., Minn., Ia., Mo.

PALAEONEILO Hall 1870

(**Nuculites constricta* Conrad). Shell nuculoid, with extended anterior and posterior ends, and more or less defined depression along umbonal slope; ligament external and contained in narrow groove along cardinal border; differs from *Nucula, Acila, Nuculana,* and *Yoldia* in lacking resilifer and in having an external ligament and post-umbonal depression externally; differs from *Nuculites* in lacking internal anterior ridge. **Dev.–Trias.**

P. muta Hall (**146**—22). **Dev.** (Hamilton–Naples): N. Y. to Pa., Va.

P. fecunda Hall (**146**—23). **Dev.** (Hamilton): N. Y. to Va., Wis.

P. (Koenenia) emarginata (Conrad) (**146**—24). **Dev.** (Hamilton–Naples): N. Y. and Appalachian region, Wis.; Portage of N. Y., Pa.

***P. constricta** (Conrad) (**146**—20, 21). **Hamilton:** Appalachian and Interior regions; **Dev.** (Marcellus–Canadaway): N. Y. to Md., Wis.

P. sulcatina (Conrad) (**146**—25). **L. Miss.:** Ohio, Mich., Ia.

NUCULANA Link 1807

(= LEDA Schumacher 1817)

(**Arca rostrata* Chemnitz). Porcelaneous, often somewhat crescent-shaped and produced posteriorly; rounded anteriorly; beaks often tumid, turned posteriorly; surface concentrically striated; hinge with a line of minute teeth, interrupted at beak by triangular resilifer; muscle impressions two and small; pallial sinus small; differs from *Nucula* in its more porcelaneous structure, in having a pallial sinus, and in the usually smooth valve margins. **Sil.–Recent** (worldwide distribution).

N. rostellata (Conrad) (**146**—29). **Dev.** (Hamilton): Ont.; N. Y. to Md.; Portage of Pa.

N. diversa (Hall) (**146**—34). **Dev.** (Hamilton–Chemung): N. Y. to Pa.; Alta.

N. bellistriata (Stevens) (**146**– 30, 31). **Penn.:** Ohio and Ala. to Colo.; **Perm.:** Kan., Tex., Wyo., Idaho (Phosphoria).

N. (Saccella) parva (Rogers) (**146**—28). **Eoc.:** Atlantic and Gulf Coastal Plain.

N. (Saccella) gabbi (Gabb) (**146**—32). **Eoc.** (Tejon): Cal.

N. washingtonensis (Weaver) (**146**—35). Shell concentrically sculptured; on each valve a narrow groove extends from beak to posterior border. **Olig.:** Wash., Cal.

N. astoriana (Henderson) (**146**—33). Growth lines incised regularly, somewhat widely spaced. **Mioc.:** Ore. (Astoria, Empire), Cal. (Monterey).

N. acuta (Conrad) (**146**—26, 27). **Mioc.:** Va. to Fla., Ore. **Plioc.:** Va. to Fla. **Pleist.:** Md. to Fla., L. Cal., Mex. **Recent:** Atlantic, Pacific (Aleutians–Gulf of Cal.).

YOLDIA Möller 1842

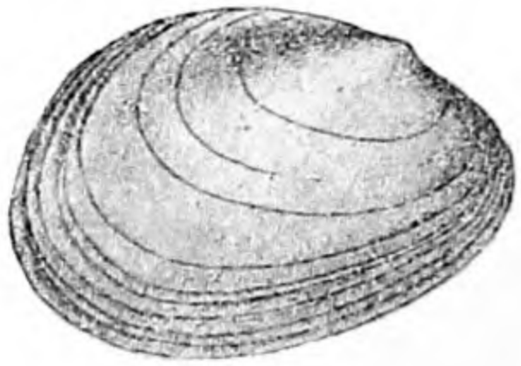
(**Nucula arctica* Gray). Compressed, lanceolate, gaping at both ends, and more or less prolonged and tapering posteriorly with a keel on posterior dorsal margin; beaks turned backward; surface nearly smooth; hinge as in *Nucula*; pallial sinus deep; differs from *Nuculana* chiefly in gaping of valves and deep pallial sinus. **Penn.–Recent** (distribution worldwide).

Y. evansi Meek and Hayden (**146**—40, 41). **Cret.**

PLATE 147

[Figures are x1 unless otherwise indicated.]

1–5, 7–9. Cucullaea spp. 1, 2. C. gigantea [Md G S, Eoc]. Exterior and interior of left valve (x0.5). **3. C. (Idonearca) truncata** [Ac N Sc Phila, SP 3]. Right valve. **4, 5. C. (Idonearca) carolinensis** [NCGS 5]. Interior and exterior of right valve. **7, 8. C. (Idonearca) vulgaris** [Md G S, U Cret]. Left valves. **9. C. (Idonearca) antrosa** [Pal N J 1]. Right valve. **6. Whitella scofieldi** [Minn G S 3 (2)]. Left valve of type (see fig. 20, this plate). **10–12. Megalomus canadensis.** Right valve and anterior view (x0.5) [Pal N Y 2]; filling of interior [Geol Canada 1863]. **13–17. Vanuxemia spp. 13, 14, 17. V. hayniana.** Safford's illustration — exterior and interior of right valves [Tenn G S, B 28]; impression of right interior [Minn G S 3 (2)]. **15, 16. V. rotundata dixonensis** [Minn G S 3 (2)]. Anterior and left side views of a filling. **18–22. Whitella spp.** [Minn G S 3 (2)]. **18, 19. W. obliquata.** Impression of left interior and interior of left valve. **20. W. scofieldi** (see fig. 6, this plate). Hinge of left valve, the type (x2). **21, 22. W. ventricosa.** Right valve and anterior view. **23, 24. Megambonia spp.** [Pal N Y 3]. Left valves of **M.? lamellosa** and **M. aviculoidea** respectively.



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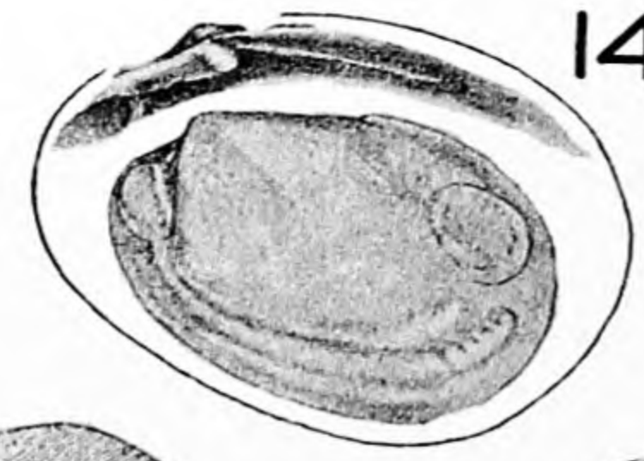

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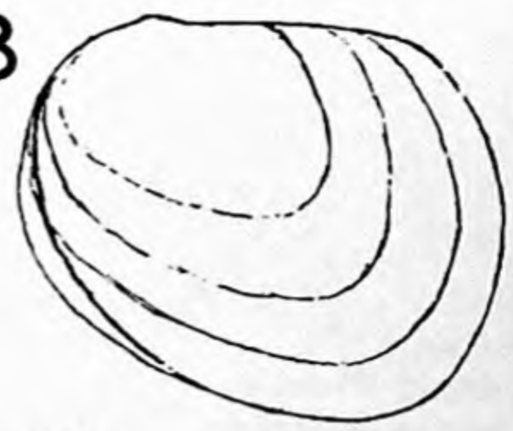

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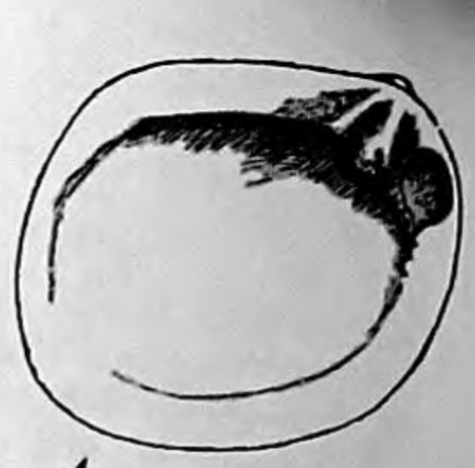

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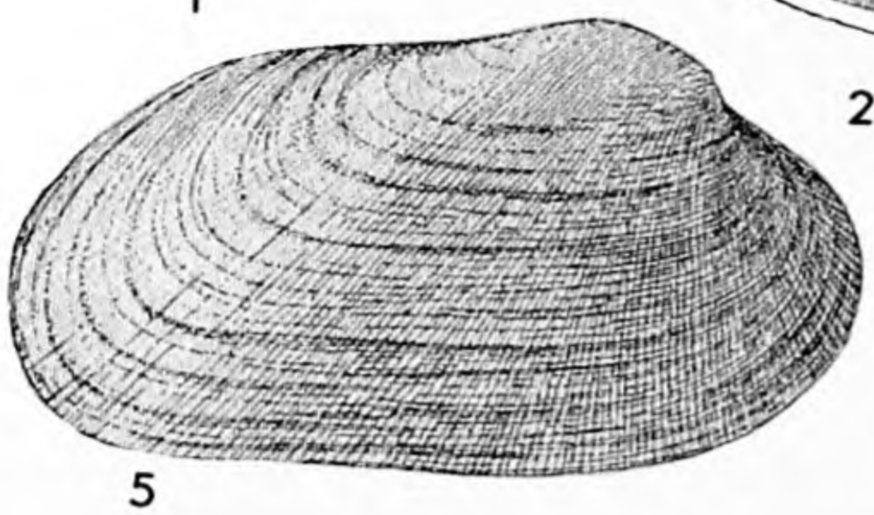

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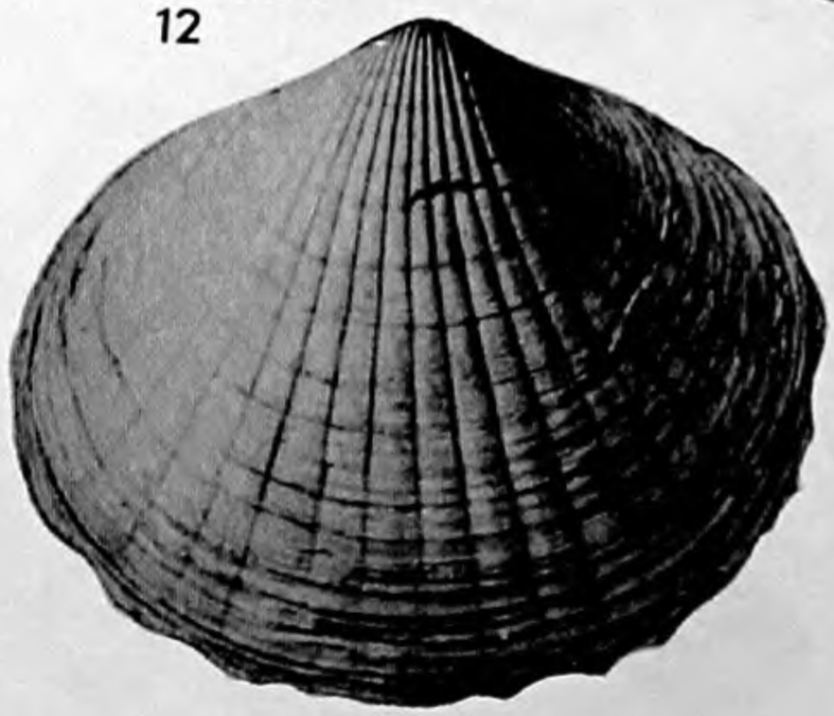

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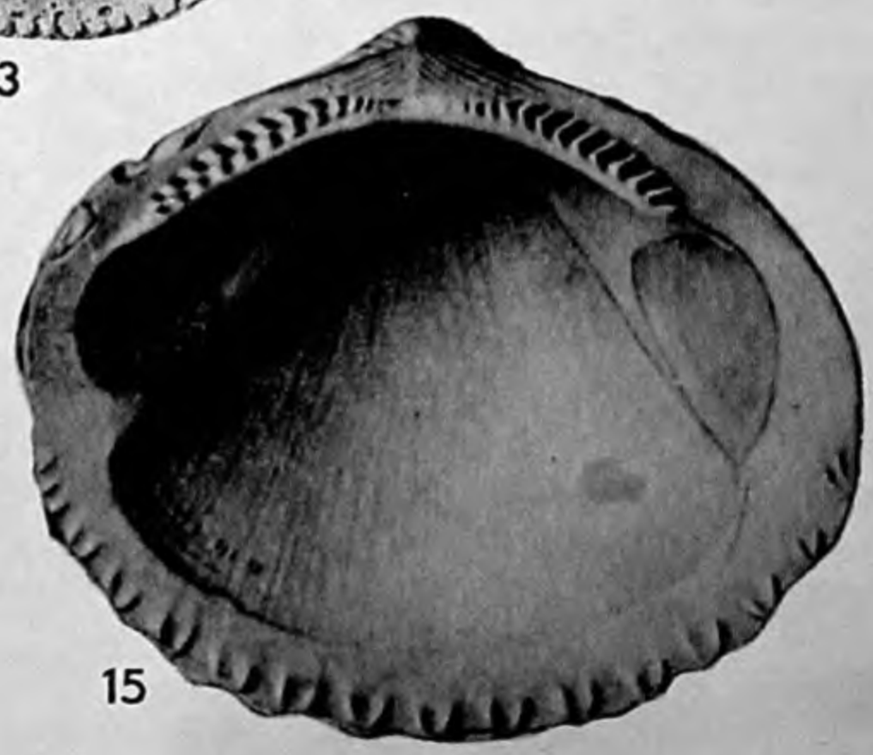

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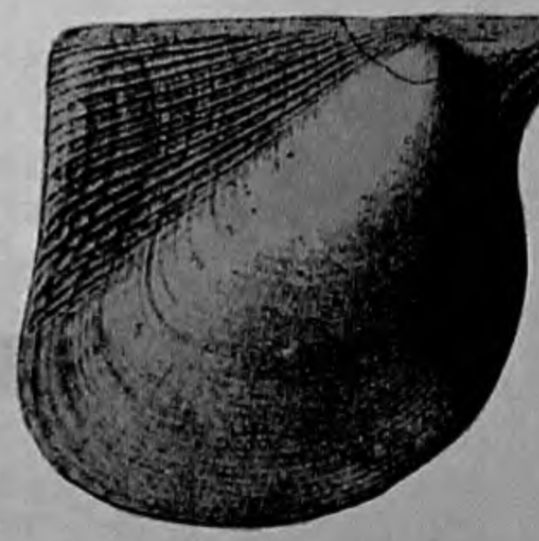

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(Montanan): Great Plains and Rocky Mountain region; Lance of N. Dak.

Y.? longifrons (Conrad) (**146**—38, 39). Shell surface polished. **U. Cret.:** Matawan of N. J. and Del.; Eutaw of Ga. to Miss.; Ripley of Tenn.

Y. scitula Meek and Hayden (**146**—42). Shell gibbous in central and umbonal regions. **U. Cret.** (Montanan): N. and S. Dak.; Alta.; Mont., N. Mex.; Lance of N. and S. Dak.

Y. eborea (Conrad) (**146**—36). Surface smooth and polished; length 12 mm. **Midway** of Gulf Coastal Plain.

Y. strigata Dall (**146**—37). Shell thin, polished. **Olig.:** Wash., Ore.

Superfamily ARCACEA

PARALLELODON Meek 1866

(= MACRODON Buckman 1844)

(**Macrodon rugosus* Lycett). Elongate to subquadrate; anterior end angular at cardinal line and rounded below; posterior rounded or obliquely subtruncate; beaks anterior to middle; hinge line long and straight; concentric striae often lamellose; hinge with several small, diverging teeth beneath the beak and two or four long, lateral teeth near posterior extremity; ligament external; pallial line simple. **Dev.–Tert.**

P. chemungensis (Hall) (**146**—46). **U. Dev.** (Chautauquan–Conewango): N. Y., Pa.

P. hamiltoniae (Hall) (**146**—44). **Dev.** (Hamilton): N. Y. to W. Va., Ohio.

P. tenuistriatus (Meek and Worthen) (**146**—45). Strong radiating lines scarcely visible anteriorly. **Penn.:** Ohio to Nev.

P. obsoletus (Meek) (**146**—43). Base a little sinuate medially and nearly parallel with hinge line. **Penn.:** W. Va. to Colo.

P. (Nanonavis) brewerianus (Gabb) (**146**—47). **U. Cret.** (Chico): abundant in Ore., Cal.; also present in **L. Cret.** of Cal.

NEMODON Conrad 1869

(**N. conradi* Johnson). Equivalve, thin, small, transversely elongate; beaks depressed and anterior to middle; hinge area narrow, long, and nearly straight; teeth consisting of a few minute granular denticles directly under beak; lateral teeth few, long, linear, parallel to hinge margin; laterals longer than in *Cucullaea*; surface marked by obscure, punctate, radiating striae and concentric lines; distinguished from *Arca* and *Parallelodon* by its teeth. **Cret.**

N. brevifrons (Conrad) (**146**—50, 51). **U. Cret.:** N. J. (Cliffwood), N. C. (Snow Hill).

N. eufaulensis (Gabb) (**146**—49). **U. Cret.:** Atlantic and Gulf Coastal Plain.

N. sulcatinus Evans and Shumard (**146**—48). **U. Cret.:** S. Dak. and Utah (Coloradoan), Mont. (Montanan).

CUCULLAEA Lamarck 1801

(**C. auriculifera*). Similar to *Arca*, but hinge has short, central, transverse or oblique teeth and two to five short lateral teeth nearly parallel to hinge line; posterior adductor scar fixed to a thin raised plate; subgenus IDONEARCA Conrad 1862 (**Cucullaea capax* Conrad, **U. Cret.** of Gulf Coastal Plain) includes forms with thicker shells and fewer teeth than typical *Cucullaea*. **Jura.–Recent.**

C. (Idonearca) vulgaris Morton (**147**—7, 8). **U. Cret.:** Matawan–Monmouth of N. J., Md.

C. (Idonearca) carolinensis (Gabb) (**147**—4, 5). **U. Cret.** (*Exogyra ponderosa* zone): Atlantic and Gulf Coastal Plain, Md. to Miss.

C. (Idonearca) antrosa Morton (**147**—9). **U. Cret.:** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

C. (Idonearca) truncata Gabb (**147**—3). Differs from *C. gigantea* in the narrower and more pointed and upright, nearly central beaks. **U. Cret.** (Chico): B. C. (Nanaimo); Ore.; Cal.

C. gigantea Conrad (**147**—1, 2). Size variable. **Eoc.:** Md., Va., Gulf states (Wilcox).

BREVIARCA Conrad 1872

(**Trigonarca saffordi* Gabb, now *B. haddonfieldensis* Stephenson). Small, suborbicular, with rounded extremities; surface smooth or marked with fine radial striae; hinge area with minute vertical striae; teeth very fine and crowded, arranged in a broad arc. **U. Cret–Paleoc.**

***B. haddonfieldensis** Stephenson (**146**—54, 55). Surface covered with fine radiating striae and concentric growth lines. **U. Cret.:** Atlantic and Gulf Coastal Plain.

B. exigua (Meek and Hayden) (**146**—52, 53). **U. Cret.** (Pierre): S. Dak., Mont., N. Mex. (Lewis).

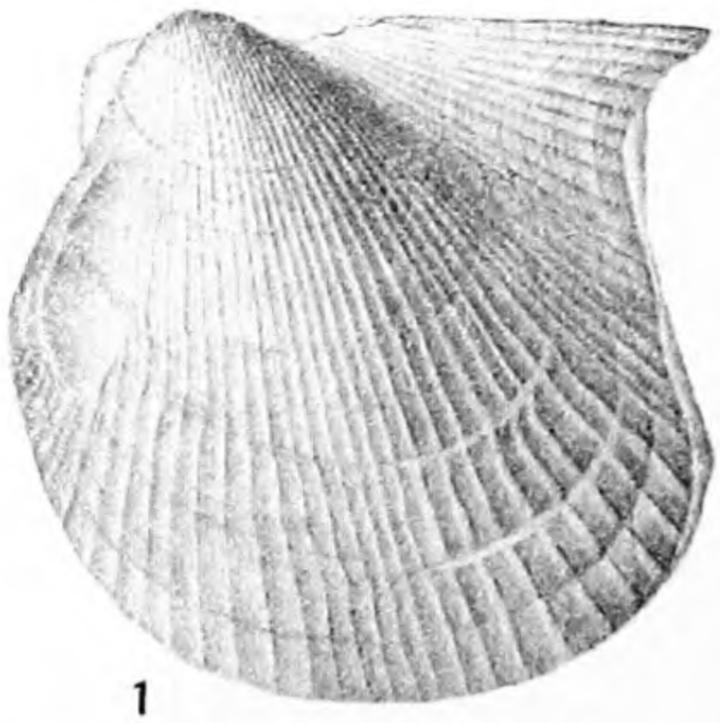
CYRTODONTA Billings 1858

(**C. rugosa*). Shell convex, equivalve; beaks prominent, incurved, situated in anterior third of shell; surface concentrically lined; hinge plate strong; cardinal teeth two to four, strongly curved, situated mostly in front of beaks; posterior lateral teeth two

PLATE 148

[Figures are x1 unless otherwise indicated.]

1–4. Ischryodonta spp. [Ohio G S 7]. **1, 2. I. unionoides.** Right valve; right interior and left side of filling. **3, 4. I. truncata.** Exterior and interior of left valve. **5–10. Arca** spp. **5, 6. A. (Barbatia) micronema** [USGS, B 106]. Right valves, exterior and interior. **7. A. (Barbatia) cuculloides** [B Am Pal 9]. Right exterior. **8. A. (Barbatia) morsei** [USGS, B 398). Left valve (x2). **9. A. (Barbatia) marylandica** [Md G S, Mioc]. Right valve. **10. A. (Arca) trilineata** [USGS, B 398]. Left valve. **11–15. Glycymeris** spp. **11. G. perrini** [GSA, SP 10]. **12, 13. G. idonea** [Md G S, Eoc]. Exterior and interior of right valve (x0.7). **14, 15. G. subovata** [USGS, PP 142]. Right and left valves. **16. Pterinea demissa** [Ohio G S 2]. Left valve. **17. Pterinea lanii** [N Y Ac Sc, An 5]. Left valve of small individual. **18–21. Cornellites** spp. **18. C. flabella** [Pal N Y 5]. Left valve. **19, 20. C. chemungensis** [Pal N Y 5]. Left and right valves (x0.6). **21. C. emacerata** [Pal N Y 2]. Left valve.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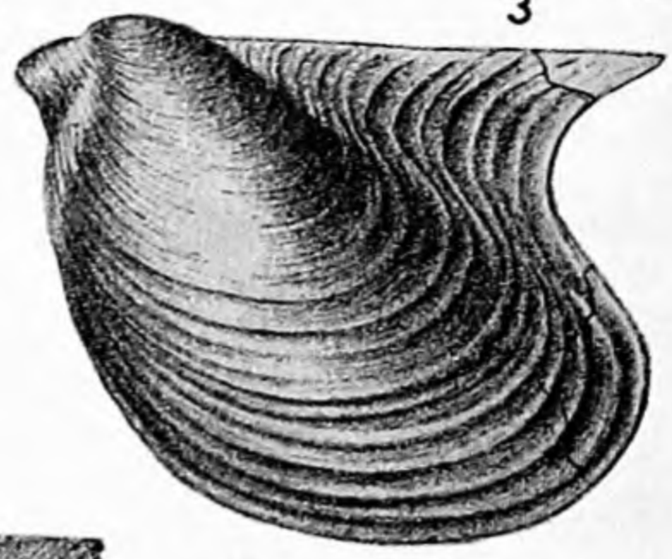
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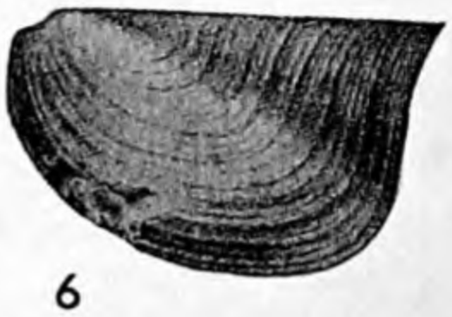
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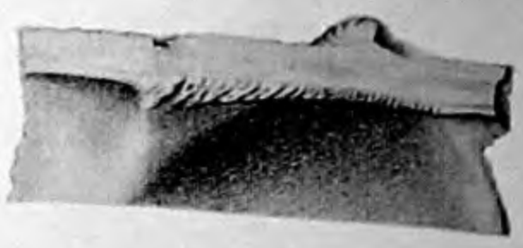
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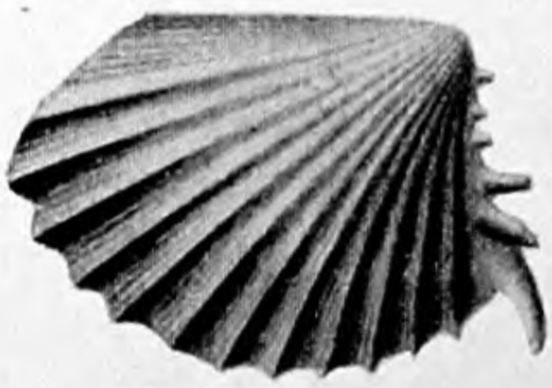
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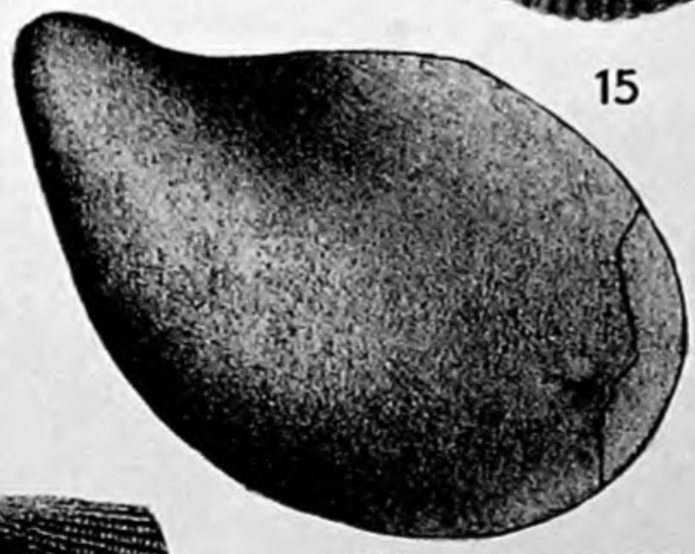
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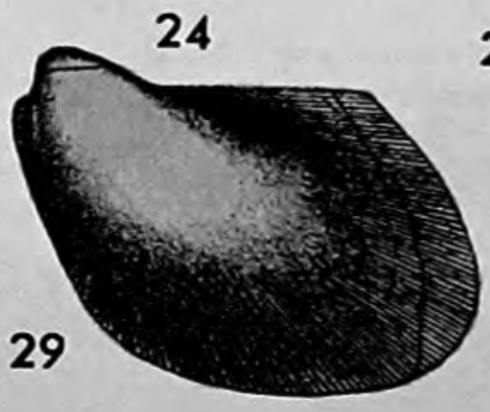
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or three, strong, elongate, slightly curved and oblique; two adductor scars present, the posterior larger but less impressed; pallial line simple. **Ord., Sil.**

C. billingsi Ulrich (**146**—58, 59). Internal umbonal furrow and ridge present. **Ord.** (Black River): N. J., Wis., Ill., Minn., Mo.

C. huronensis Billings (**146**—56, 57). **Ord.** (Black River): Que.; Va., Ky., Tenn., Wis., Minn.

C. grandis (Ulrich) (**146**—60). Large; surface smooth; marked with fine concentric growth lines. **Ord.** (Trenton): Ky., Tenn., Wis., Minn., Ia.

MEGALOMUS Hall 1852

(**M. canadensis*). Shell thick, equivalve, with three or four toothlike folds at hinge above the deep muscle pit. **Sil.**

***M. canadensis** Hall (**147**—10–12). Shell ovoid, depth equal to height; surface concentrically striated; the space within the shell, beneath the beaks and extending over halfway to base of valves, is much thickened so that internal fillings show two projections at the hinge line. **Sil.** (Guelph): Ont.; Ohio, Ind., Wis.; Alaska.

MEGAMBONIA Hall 1859

(**M. cardiiformis*). Equivalve or nearly so, gibbous, inequilateral, with shorter anterior end which bears a strong muscle impression; posterior extremity expanded and compressed, frequently winglike; surface marked with concentric growth lines and often with radiating striae; teeth numerous in anterior portion of hinge; differs from *Ambonychia* in the strong anterior muscle impression and the numerous teeth in anterior position. **Sil.–Penn.**

M. aviculoidea Hall (**147**—24). Distinguished from similar species of other genera by very small anterior ear, strong anterior muscle scar, which is characteristic of the genus, and posterior wing, which is not defined from rest of shell by sinus or change of ornamentation. **L. Dev.** (Helderbergian): Coeymans of N. Y., N. J.; southwestern Ellesmere Land, Arctic America.

M.? lamellosa Hall (**147**—23). Both ears separated from body of shell by a depression. **Dev.** (Oriskany): Ont.; N. Y. to Md., W. Va.

VANUXEMIA Billings 1858

(**V. inconstans*). Differs from *Cyrtodonta* in having more nearly terminal beaks, and in having anterior adductor muscle scars excavated out of hinge plate; an internal umbonal ridge is well developed. **Ord.**

V. dixonensis Meek and Worthen (**147**—15, 16). **Ord.** (Black River): Wis., Ill., Minn., Mo.

V. hayniana (Safford) (**147**—13, 14, 17). **Ord.** (Trenton): Ky., Tenn., Ill., Minn., Mo.

WHITELLA Ulrich 1890

(**W. obliquata*). Differs from *Cyrtodonta* in having a thinner shell, a longitudinally striated area extending posteriorly from the beaks, an umbonal ridge, anterior teeth merely two to five oblique folds and posterior lateral missing; the internal ligament is supported by a ridge in each valve which is at times mistaken for a posterior tooth. **Ord., Sil.**

W. scofieldi Ulrich (**147**—6, 20). **Ord.:** Black River of Wis., Minn.; L. Trenton of Ill., Mo.

W. ventricosa (Hall) (**147**—21, 22). **Ord.** (Trenton): Que.; N. Y., Minn.

***W. obliquata** Ulrich (**147**—18, 19). **Ord.** (Richmond): Ohio, Ind., Minn.

ISCHYRODONTA Ulrich 1890

(**I. truncata*). Valves thick; beaks small, anterior; hinge plate wide, without posterior lateral teeth but with strong cardinal teeth in left valve and one large one in the right; ligament internal, posterior to beaks; anterior muscle scar sharply defined on inner side by a ridge extending from cardinal teeth to base of scar. **Ord.**

I. unionoidea (Meek) (**148**—1, 2). **U. Ord.:** Pulaski shales of Ont., N. Y., and Pa.; Maysville (Bellevue) of Ohio and Ky.

***I. truncata** Ulrich (**148**—3, 4). Surface marked by a few sublamellose growth lines. **U. Ord.** (Richmond): Whitewater of Ohio and Ind.

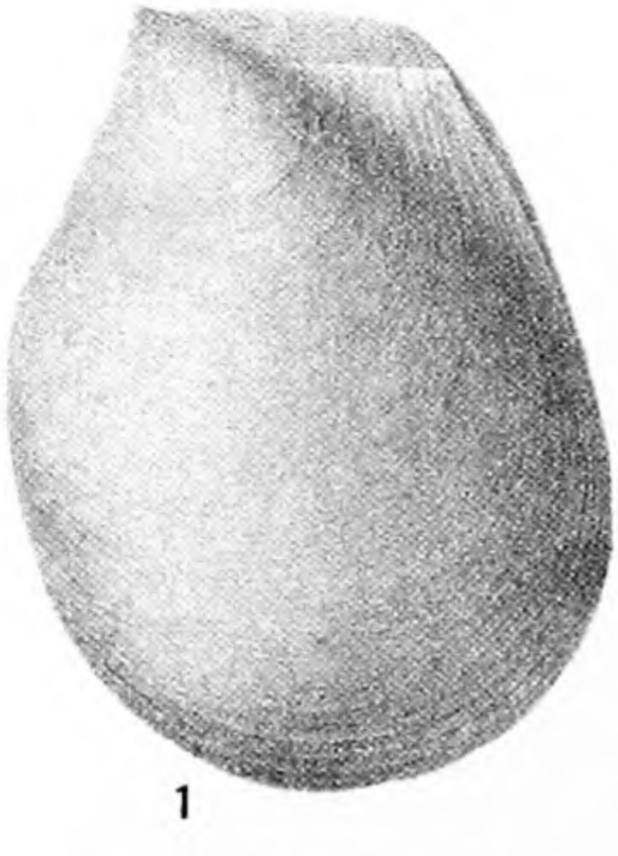
ARCA Linnaeus 1758

(**Arca antiquata*). Shell thick, ventricose, trapezoidal; beaks conspicuous, distant, separated by an area which has many ligamental grooves converging from hinge margins to beaks; surface radially sculptured; hinge line wide, straight, transversely dentate; teeth small and similar, taxodont, approximately vertical to margin of valve. (In BARBATIA Gray 1842 (**Arca barbata* Linnaeus) the central teeth are smallest and vertical, the lateral teeth becoming

PLATE 149

[Figures are x1 and after Hall [Pal N Y 5] unless otherwise indicated.]

1. Limoptera macroptera. Left valve. **2–6. Leiopteria** spp. **2, 3. L. laevis.** Right and left valves. **4. L. rafinesquii.** Left valve. **5. L. dekayi.** Left valve. **6. L. subplana** [Pal N Y 2]. Left valve. **7, 8. Glyptodesma erectum.** Hinge showing striated ligamental area and cardinal folds; left valve. **9, 10. Actinopterella radialis** [USGS, PP 89]. Left exterior; impression of right interior. **11, 12. Doziorella gouldi** (x3) [GSA, B 51]. Small left valve and interior of left valve. **13, 14. Leptodesma** spp. Left valves of **L. rogersi** and **L. agassizi** respectively. **15. Lunulacardium curtum.** Right valve. **16. Pterochaenia fragilis** [N Y St Mus, M 6]. Right valve (x3). **17–19. Loxopteria** spp. [N Y St Mus, M 6]. **17. L. corrugata.** Left valve (x2). **18, 19. L. dispar.** Right valve (x2) and left (x1.5). **20, 21. Honeoyea erinacea** [N Y St Mus, M 6]. Right valve with spines (x5); cardinal view of left valve (x3). **22. Ambonychia amygdalina** [Minn G S 3 (2)]. Impression of left interior. **23–28. Byssonychia** spp. **23. B. radiata** [Minn G S 3 (2)]. Anterior view (p = pallial line). **24. B. radiata** [Ohio G S 2]. Left valve. **25, 26. B. intermedia** [Minn G S 3 (2)]. Left valve and cardinal view. **27, 28. B. radiata** [N Y St Mus, B 272]. Right valve and rostral portion of left (x5). **29, 30. Ambonychia bellistriata** [Minn G S 3 (2)]. Impression of left interior and anterior view of a filling. **31–33. Mytilarca** spp. **31. M. fibristriata.** Left valve. **32, 33. M. chemungensis.** Left valve with beak partly broken away, showing cardinal teeth; left interior showing striated hinge area.



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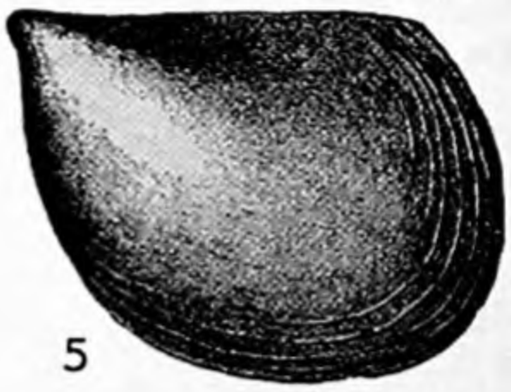

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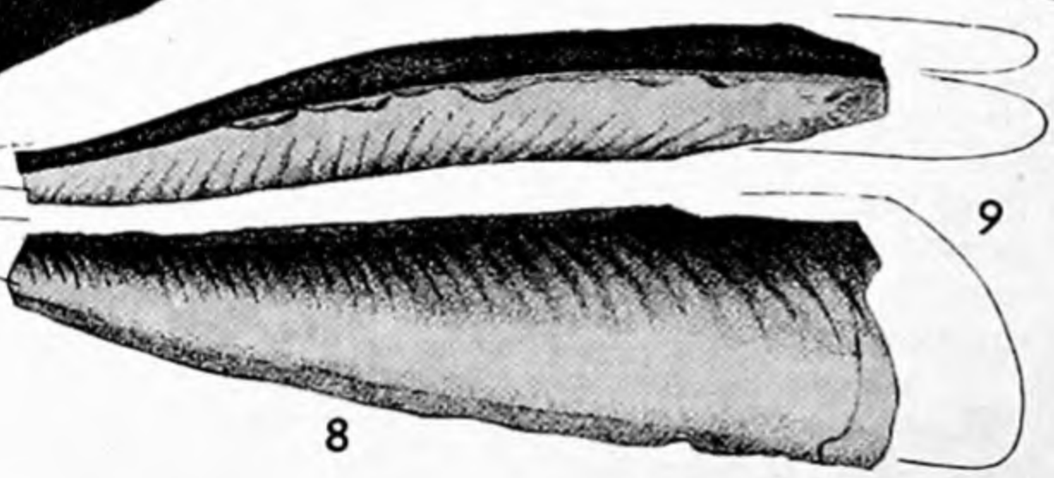

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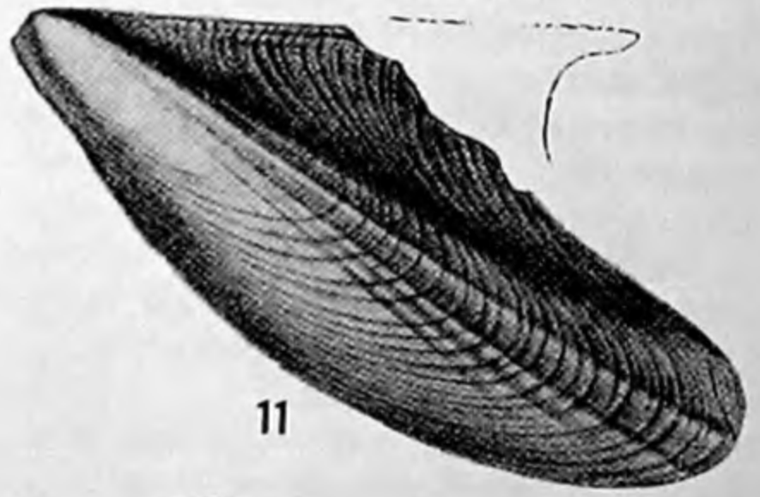

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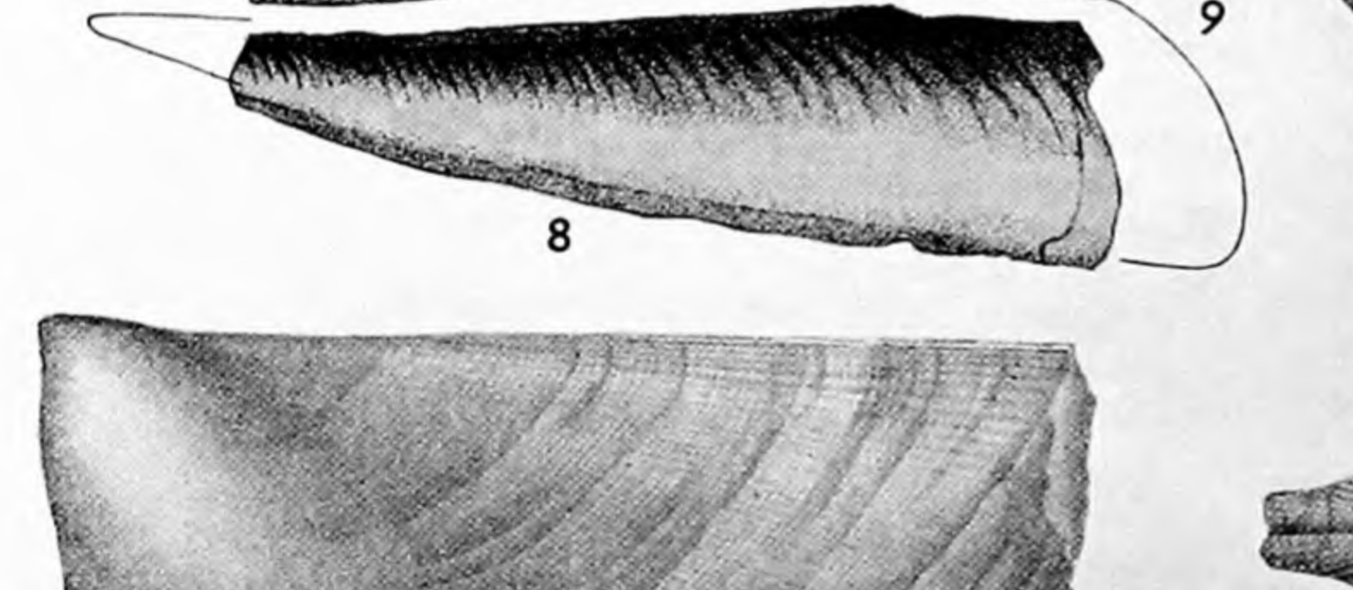

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gradually larger, more distant, and more oblique; radial sculpture of shell surface fine; in *Arca ss* it is coarse). **Jura.–Recent.**

A. (Barbatia) micronema (Meek) (**148**—5, 6). **U. Cret.** (Coloradoan): Wyo., Utah, Tex., N. Mex.

A. (Barbatia) cuculloides (Conrad) (**148**—7). Valves marked by strong, subcentral sinus; posterior side elongated, strongly ribbed, and carinated. **Eoc.:** Ga., Ala., Miss., Ark. **L. Olig.:** Miss.

A. (Barbatia) morsei Gabb (**148**—8). Small; radial plications narrow. **U. Eoc.:** Wash. to Cal. (Tejon).

A. (Barbatia) marylandica Conrad (**148**—9). **U. Olig.:** Fla. **Mioc.:** N. J., Md., Fla.

A. (Arca) trilineata Conrad (**148**—10). **Mioc.:** Wash., Ore., Cal. **Plioc.:** Cal.

GLYCYMERIS Costa 1778
(= PECTUNCULUS Lamarck 1799)

(**Arca glycymeris* Linnaeus). Shell thick, suborbicular, almost equilateral; umbos central, slightly curved posteriorly, separated by a small triangular area provided with diverging grooves for the ligament; hinge with an arched row of strong, transverse teeth, obliterated at the center in older forms by growth of the area; valve margins crenulate inside; adductor scars subequal; pallial line entire or with a very small sinus. **Cret.–Recent,** with maximum in the **Mioc.**

G. idonea (Conrad) (**148**—12, 13). **Eoc.:** Md. (Pamunkey), Ga. and Ala. (Wilcox).

G. perrini Dickerson (**148**—11). **Eoc.:** Ore. (U. Umpqua), Cal.

G. subovata (Say) (**148**—14, 15). **Mioc.** (Calvert–Yorktown): Md. to Fla.

Section C. SCHIZODONTA
Superfamily PTERIACEA

PTERINEA Goldfuss 1832

(**P. laevis*). Inequivalve, inequilateral; left valve convex, right flat; hinge margin constricted into ears; surface without radial sculpture; ligament area extending on both sides of beak and longitudinally grooved; anterior teeth transverse; posterior elongate, nearly parallel to hinge line; dimyarian; anterior muscle scar small but strong; pallial line simple. **Ord.–Penn.**

P. (***Caritodens**) **demissa** (Conrad) (**148**—16). Distinguished by its strong concentric growth lines and large anterior ear. **U. Ord.** (Maysville–Richmond): Que.; N. Y., Pa., Ohio, Ind., Ky., Tenn.

P. lanii Grabau (**148**—17). **U. Sil.** (L. Monroan): Ont.; Mich., Ohio, Wis.

CORNELLITES Williams 1908

(**Pterinea fasciculata* Goldfuss). Differs from *Pterinea* in having valves radially sculptured. **Ord.–Penn.**

C. emaceratus (Conrad) (**148**—21). Right valve smooth with striated wing. **Sil.** (Niagaran): N. S., Ont.; Md., W. Va.

C. flabella (Conrad) (**148**—18). Surface of right valve lacking rays except weak ones on posterior wing. **Dev.** (Onondaga–Hamilton): N. Y. to Md., Ind., Mich.

C. chemungensis (Conrad) (**148**—19, 20). Valves often less oblique than shown in figures. **Dev.** (Portage, Chemung to Canadaway): N. Y. to Md., W. Va.

LIMOPTERA Hall 1869

(**Lima macroptera* Conrad). Differs from *Cornellites* in its subquadrate shell and less conspicuous separation of the posterior wing from body of shell. **Dev.**

***L. macroptera** (Conrad) (**149**—1). **Dev.** (Hamilton): Ont.; N. Y., Ohio.

ACTINOPTERELLA Williams 1908

(**Pterinea radialis* Clarke (pars)). Both valves convex, surface with numerous radiating lines; cardinal and lateral teeth strong. **Ord.–Dev.**

***A. radialis** (Clarke) (**149**—9, 10). **L. Dev.** (Helderbergian): Me. (Chapman).

GLYPTODESMA Hall 1883

(**Avicula erecta* Conrad). Like *Pterinea* but erect or only moderately oblique, with wings elongate and narrow, and less strong limitation between body of shell and wing; surface concentrically striated. **Dev.**

***G. erectum** (Conrad) (**149**—7, 8). Anterior wing limited by distinct furrow; hinge line often greatly extended. **Dev.** (Hamilton): Ont.; N. Y., Pa., Ohio, Ind.

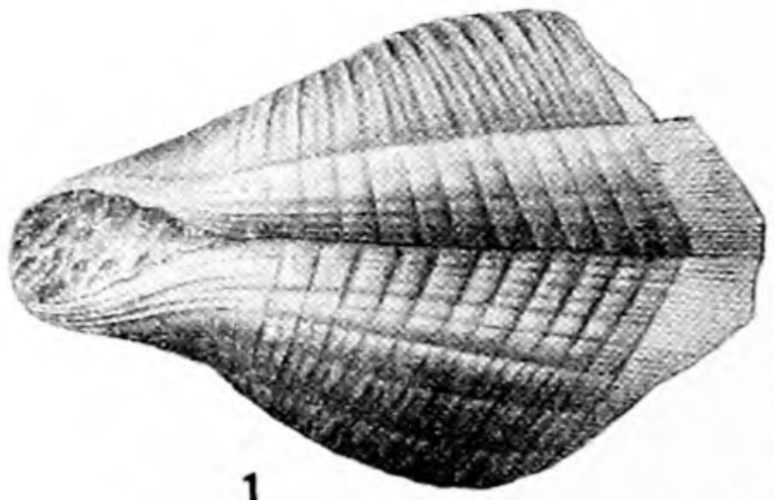
LEIOPTERIA Hall 1883

(**L. dekayi*). Shell aviculoid; ligament area longitudinally striated; one or two oblique lateral teeth present, no cardinal teeth; cavity of beak partly separated from anterior end by a short partition immediately in front of the anterior adductor impression; surface without rays. **Sil.–Miss.**

PLATE 150

[Figures are x1 unless otherwise indicated.]

1–3. Plethomytilus spp. [Pal N Y 5]. **1. P. oviformis.** Left valve showing striated hinge area and three posterior teeth on wing. **2, 3. P. ponderosus** (x0.5). Profile view of a filling; left valve. **4, 5. Clionychia** spp. [Minn G S 3 (2)]. Left valve of **C. undata** and **C. lamellosa** respectively. **6. Gosselettia triquetra** [Pal N Y 5]. Large left valve showing ligamental area. **7. Pinna laqueata** (x0.6) [Pal N J 1]. **8–10, Aviculopinna** spp. [Kan G S 6]. **8, 9. A. peracuta** (x0.5). Lateral and dorsal views. **10. A. americana.** Left valve. **11. Gervillia montanaensis** [USGS Ter, Wyo, Idaho, 1878]. Small left valve. **12. Palaeopinna flabella** [Pal N Y 5]. Left valve. **13, 14. Gervilliopsis ensiformis** [Pal N J 1]. Left interior and basal view of anterior end. **15–18. Conocardium** spp. [Pal N Y 5]. **15–17. C. cuneus.** Right side, cardinal, and ventral views of a small shell of the var. **trigonale** Hall. **18. C. ohioense.** Left valve (x2). **19. Bakewellia parva** [USGS, W 100th Mer 4]. Left valve (x3). **20, 21. Gervillia** spp. **20. G. subtortuosa** [USGS Ter 9]. Internal and hinge views of left valve of type (x0.5). **21. G. propleura** [USGS, B 106]. Left valve.



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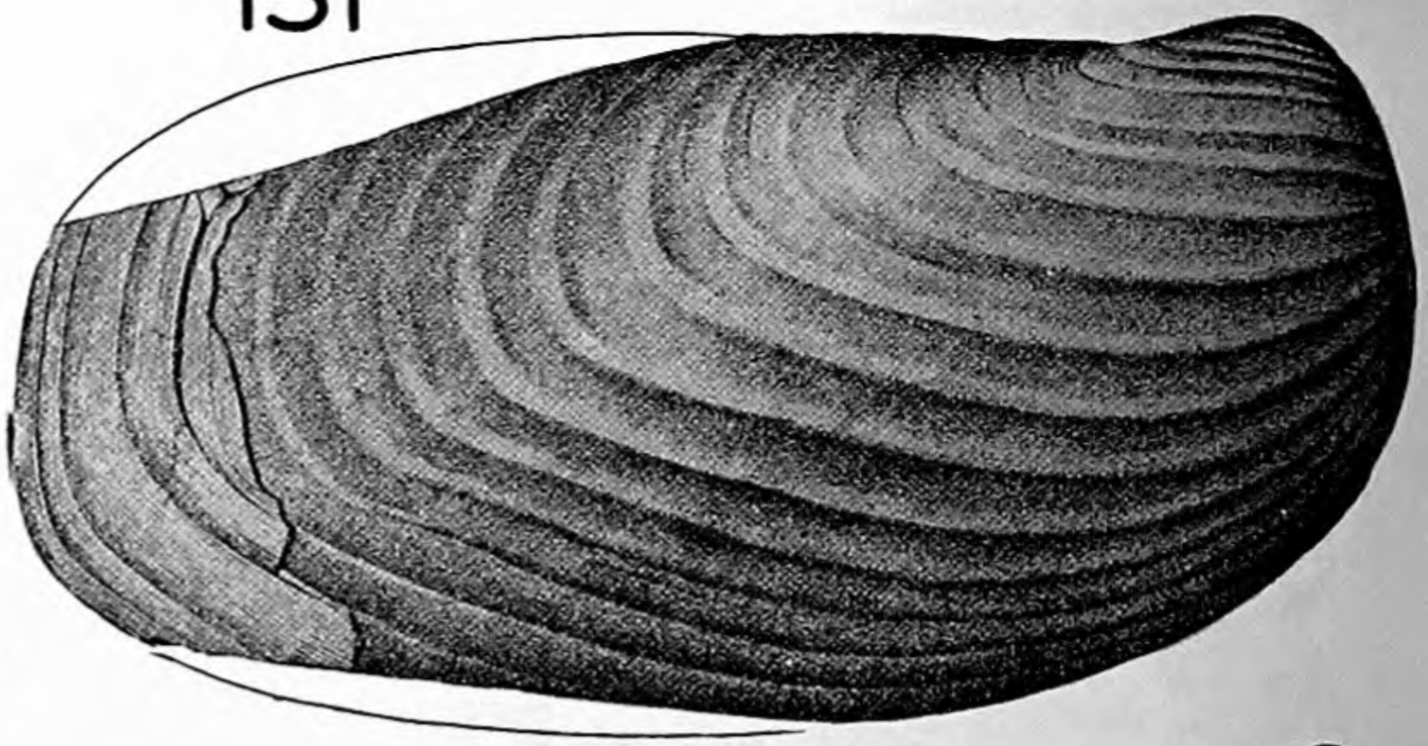

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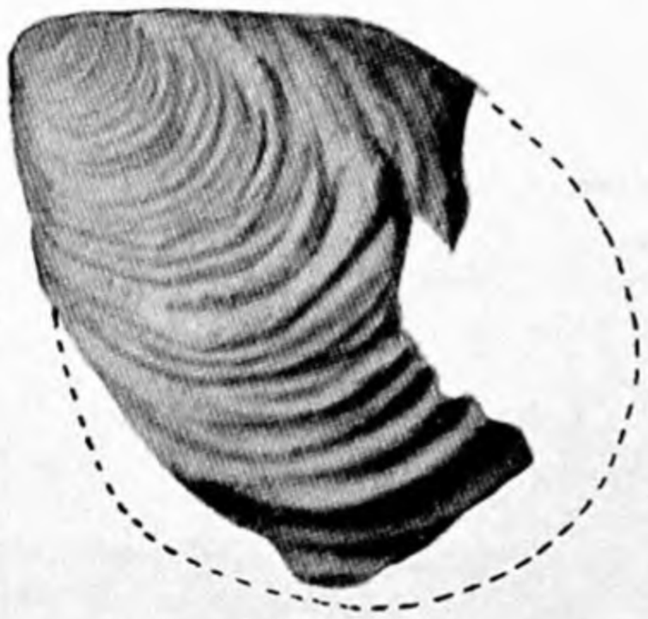

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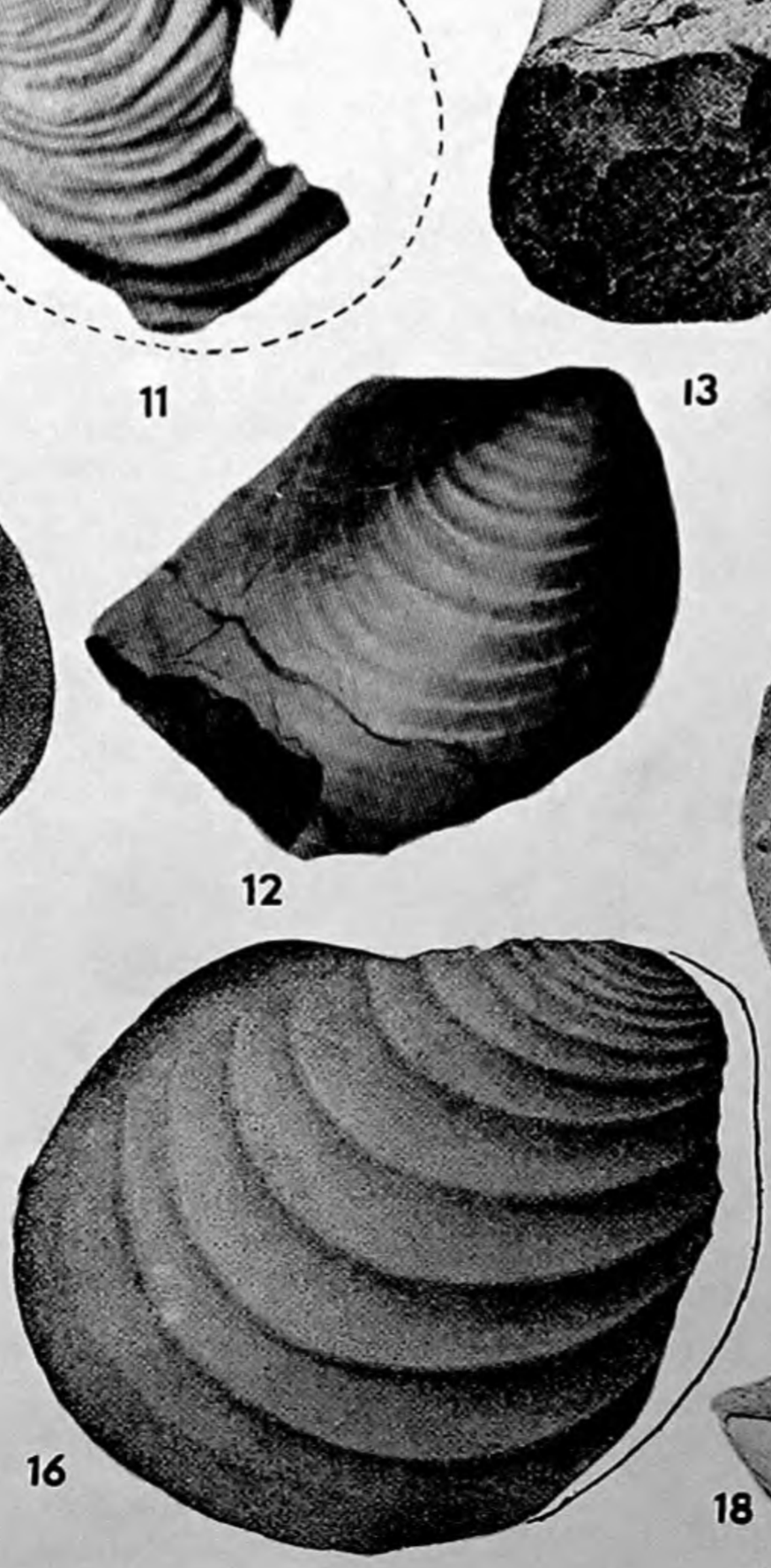

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L. subplana (Hall) (**149**—6). **Sil.** (Niagaran): Ont.; N. Y.; Cobleskill of N. Y.

L. laevis Hall (**149**—2, 3). **Dev.** (Onondaga–Marcellus): N. Y., Pa., Md.

L. rafinesquii Hall (**149**—4). **Dev.** (Hamilton): Ont.; N. Y., Ohio, Wis. Rarely recurrent in Ithaca.

***L. dekayi** Hall (**149**—5). **Dev.** (Hamilton): N. Y., Ohio.

DOZIERELLA Newell 1940

(**Bakewellia gouldii* Beede). Unornamental, pterioid, with several chevron ligament grooves; one to two posterior lateral teeth and three to four anterior cardinal ones; no byssal notch. **Perm.**

***D. gouldi** Beede (**149**—11, 12). **U. Perm.:** Whitehorse of Okla. and Tex.; Carlsbad of N. Mex.; Phosphoria of Wyo.

LEPTODESMA Hall 1883

(**L. potens*). Differs from *Pterinea* in having anterior ear acute instead of rounded; surface without rays; umbonal region prominent. **Sil.–Miss.**

L. rogersi Hall (**149**—13). **M. Dev.:** N. Y. to Md., Ia.

L. agassizi Hall (**149**—14). **U. Dev.** (Chemung): N. Y.

LOXOPTERIA Frech 1891

(**Avicula dispar* Sandberger). Inequivalve, very inequilateral; anterior muscle scar small; ligament external; teeth obscure; left valve very convex, with arched and incurved beak twisted backward; right valve depressed-convex, appearing like the operculum of the larger valve; this valve expands into a small posterior wing. **Dev.**

L. dispar (Sandberger) (**149**—18, 19). **U. Dev.:** N. Y. (Canadaway); Germany.

L. corrugata Clarke (**149**—17). **Dev.** (Canadaway): N. Y., Pa.

LUNULACARDIUM Muenster 1840

(**L. semistriatum*). Usually triangular, with acute and abruptly terminal, posteriorly turned beaks; shell usually obliquely truncate in front; a deeply impressed area posterior to the beaks for the conspicuous byssal opening; surface with concentic striae and usually radii; teeth absent; pallial line simple. **Dev., Miss.**

L. curtum Hall (**149**—15). Similar radii on each valve. **Dev.** (Hamilton, possibly also in Onondaga): N. Y., Pa., W. Va.

HONEOYEA Clarke 1904

(**H. erinacea*). Differs from *Lunulacardium* in minute inflected beak, and abrupt slope from sides of umbo to hinge line; anterior to beak is a byssal notch and posterior to beak is a similar concave area but this contains no such opening between the valves; surface covered with radiating ribs. **Dev.**

***H. erinacea** Clarke (**149**—20, 21). **Dev.** (Naples–Chemung): N. Y.

PTEROCHAENIA Clarke 1904

(**Avicula fragilis* Hall). Valves thin; surface marked only with fine concentric growth lines; all radiating lines lie on inner surface of valves and may be outwardly visible by translucence; beaks turned forward; anterior to beaks and bounding conspicuous byssal opening is a winglike flange which is widest at beak, becoming narrower toward shell base. **Dev.**

***P. fragilis** (Hall) (= **Lunulacardium fragile**) (**149**—16). **Dev.** (Marcellus–Conneaut): N. Y. to Md., W. Va., Ind.

AMBONYCHIA Hall 1847, emend Ulrich 1897

(**A. bellistriata*). Equivalve and very inequilateral; beaks nearly or quite terminal; no anterior wing present but posterior extremity somewhat winged; valves ventricose, thin, tightly closed all around; surface marked by fine radiating striae crossed by concentric growth lines and obscure undulations; two small, oblique cardinal teeth present; lateral teeth absent; ligament external; posterior adductor scar large and bilobed; no anterior adductor present; pallial line simple; differs from *Clionychia* in more convex valves, more strongly incurved beaks, radial striations, and in possessing a small, lobelike cavity beneath or just in front of the beaks separated from the main umbonal cavity by a thin partition (clavicle), mere thickening of the valve margins. **Ord.**

***A. bellistriata** Hall (**149**—29, 30). **Ord.** (Trenton): N. Y., Ill., Minn., Mo.

A. amygdalina Hall (**149**—22). **Ord.** (Trenton): Ill., Minn., Mo.

BYSSONYCHIA Ulrich 1893

(**Ambonychia radiata* Hall). Like *Ambonychia*, but differing in its more erect form, sharper beaks, and in having a byssal opening in upper half of anterior side, and two of three slender lateral teeth situated posteriorly; no anterior clavicle or anterorostral cavity; radiating lines usually stronger also. **Ord.**

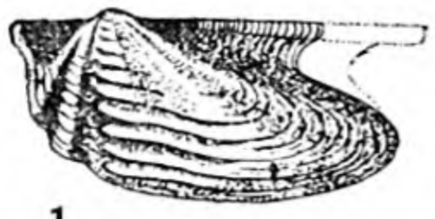
B. intermedia (Meek and Worthen) (**149**—25, 26). **Ord.** (Galena): Ky., Wis., Ill., Mo.; Man.

***B. radiata** (Hall) (**149**—23, 24, 27, 28). **U. Ord.** (Maysville–Richmond): Anticosti; Que.; N. Y. to Va., Ohio, Ind. to Tenn.

PLATE 151

[Figures are x1 and from Stanton [USGS, B 106] unless otherwise indicated. Some of Stanton's figures are after Meek and White.]

1. Conocardium cuneus [Pal N Y 5]. Ventral view. **2–18. Inoceramus** spp. **2. I. undulato-plicatus** (x0.5) [USGS, PP 126]. **3, 4. I. dimidius.** Left valve and front view. **5. I. simpsoni.** Right valve of type (x0.5). **6. I. fragilis.** Right valve (x0.5). **7, 8. I. gilberti.** Two views of a left valve (x0.5). **9, 10. I. unabundus** [USGS Ter 9]. Two views of a left valve (x0.5). **11. I. comancheanus** [USGS, PP 131]. Left valve. **12. I. sagensis** [Owen: Rp G S Wis, Ia, Minn]. Right valve of type (x0.5). **13, 14. I. (Volviceramus) umbonatus** (x0.25) [USGS Ter 9]. Dorsal and anterior views of a filling of a left valve. **15. I. labiatus.** Small right valve. **16. I. deformis.** Right valve (x0.5). **17, 18. I. barabina** [USGS Ter 9]. Left valve and dorsal view of same.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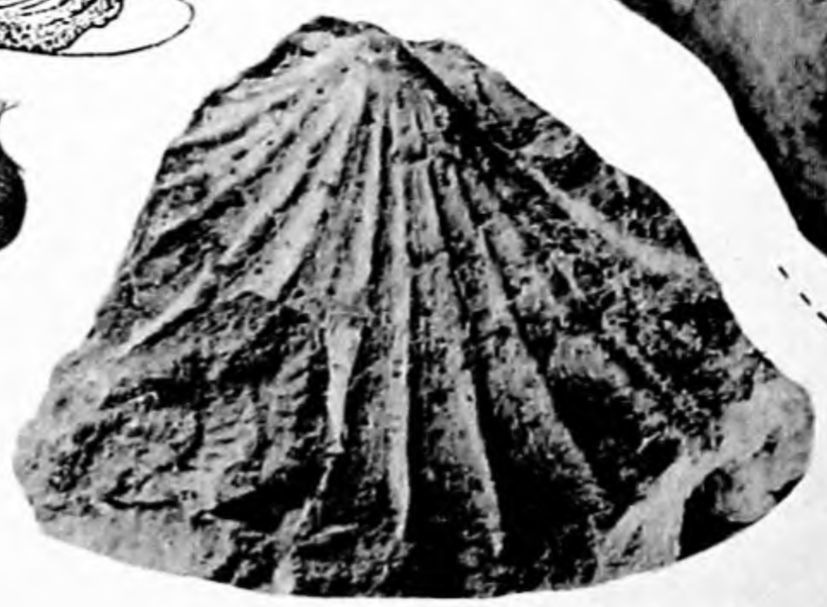
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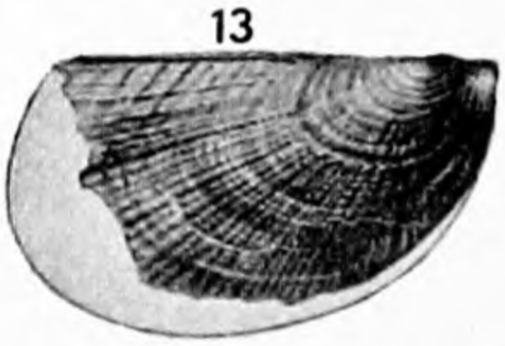
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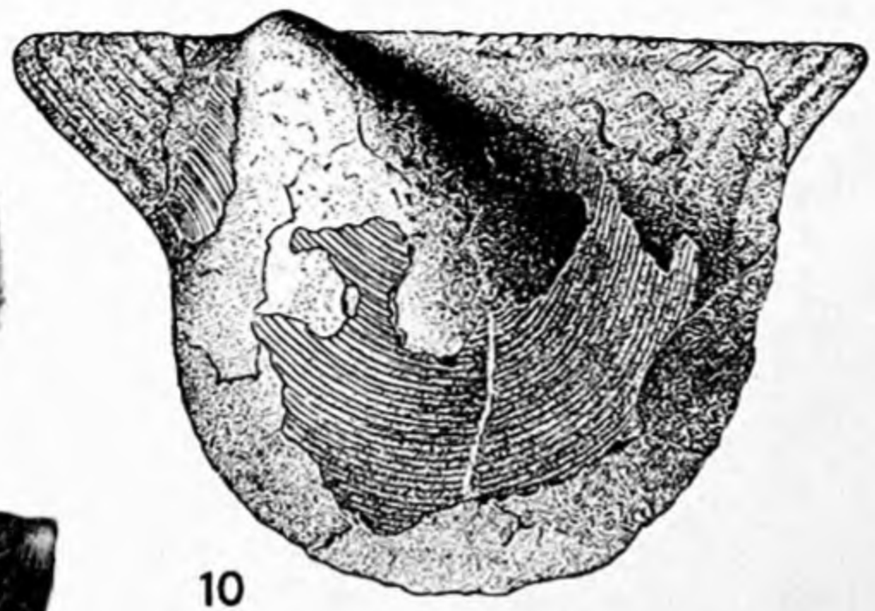
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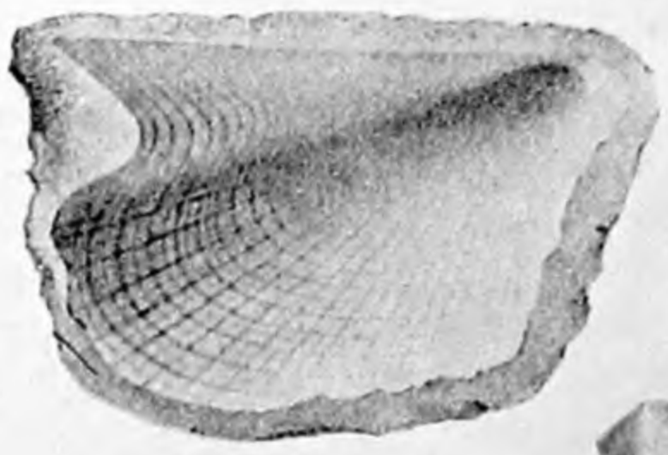

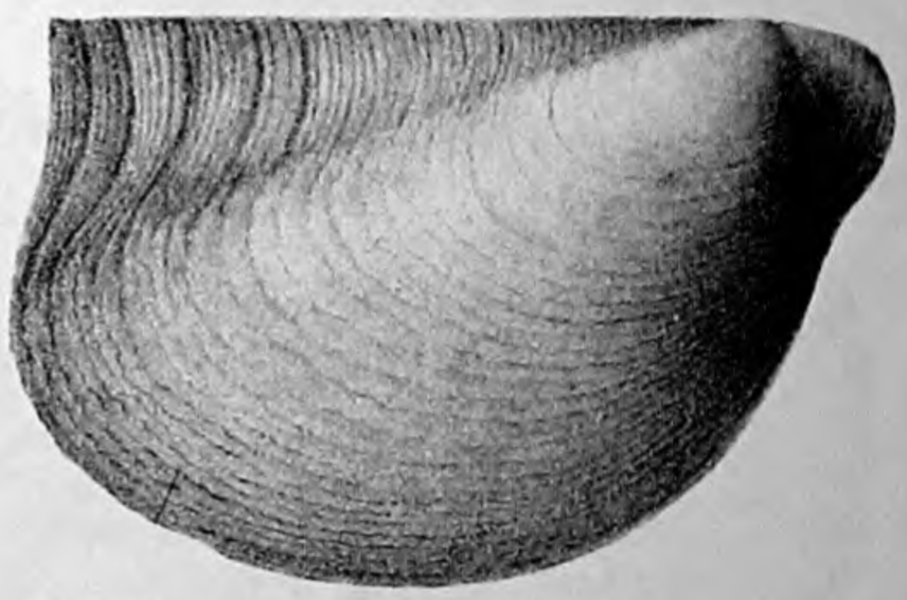
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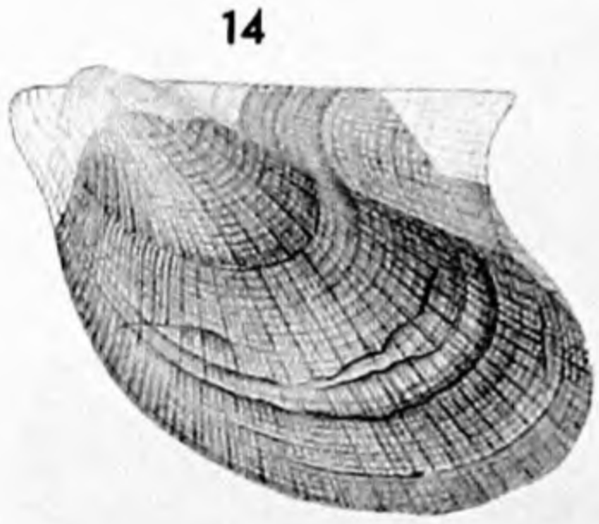
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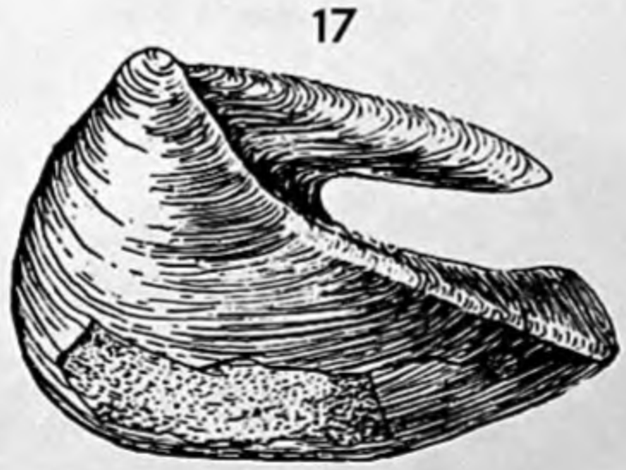
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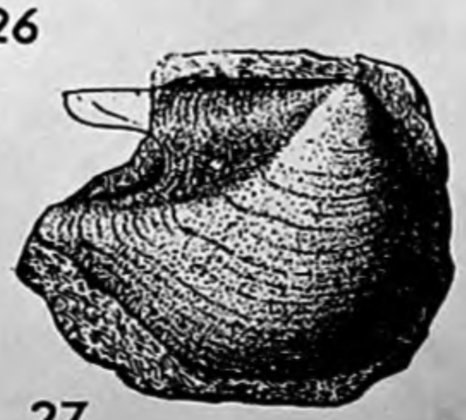
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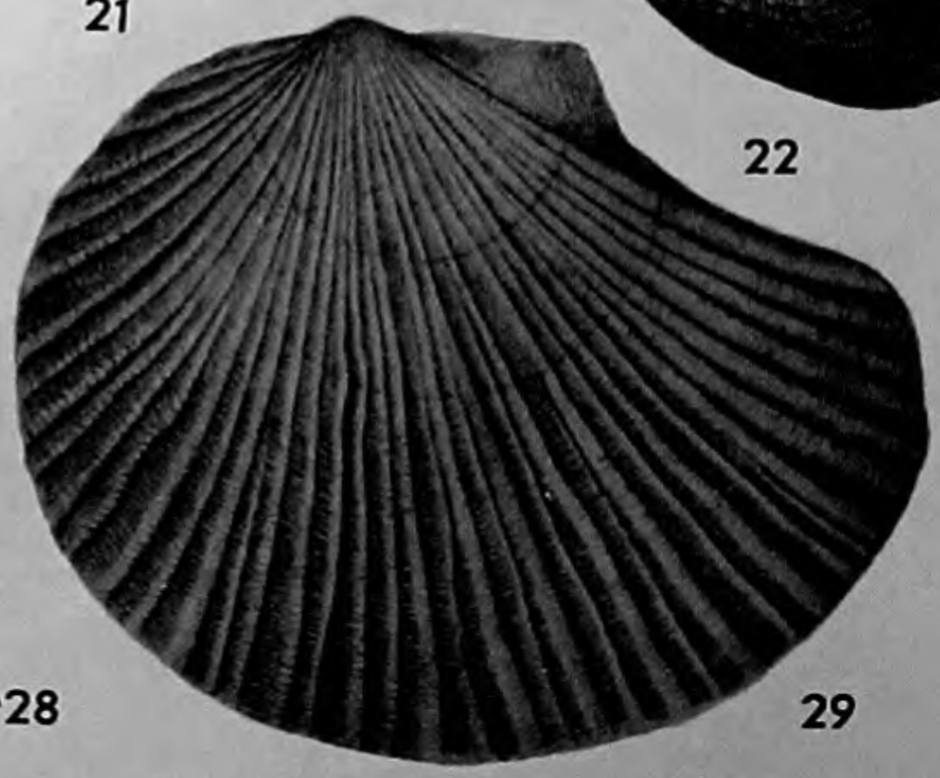
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MYTILARCA Hall 1869

(**Inoceramus chemungensis* Conrad). Differs from *Plethomytilus* in having cardinal teeth. **Sil.–Miss.**

***M. chemungensis** (Conrad) (**149**—32, 33). **Dev.** (Chautauquan): N. Y.

M. fibristriata White and Whitfield (**149**—31). **L. Miss.:** Mich., Ohio, Ia.

PLETHOMYTILUS Hall 1883

(**P. ponderosa*). Equivalve, very inequilateral; hinge line straight; an obscure posterior ear present; surface with concentric striae, ligament external, its area striated; lateral teeth oblique; cardinal teeth lacking; pallial line simple. **Sil., Dev.**

***P. ponderosus** Hall (**150**—2, 3). **Dev.** (Onondaga–Hamilton): Ont.; N. Y., Ohio.

P. oviformis (Conrad) (**150**—1). **Dev.** (Hamilton): N. Y. to Md.

CLIONYCHIA Ulrich 1892

(**Ambonychia lamellosa* Hall). Like *Ambonychia*, but differing in having smaller and but slightly incurved beaks, in possessing concentric ornamentation alone, an absence of teeth, and in the thickening of the hinge margins anteriorly, producing in internal fillings a well marked impression in this part; differs from *Mytilarca* in its less oblique form and in the absence of teeth. **Ord.**

***C. lamellosa** (Hall) (**150**—5). Concentric growth lines lamellose. **Ord.** (Black River): Wis., Ill., Minn.

C. undata (Emmons) (**150**—4). Subquadrate; concentric undulations. **Ord.** (Trenton): N. Y., Minn.

GOSSELETTIA Barrois 1882

(**G. devonica*). Thicker shelled, with heavier and more numerous cardinal and lateral teeth than *Byssonychia*. **Dev.**

G. triquetra (Conrad) (**150**—6). An excellent guide to the **Dev.** (Hamilton): N. Y., Mich. (Traverse), Ohio.

AVICULOPINNA Meek 1864

(**Pinna prisca* Münster = *Avicula pinnaeformis* Geinitz). Differs from *Pinna* in that its beaks are farther removed from extreme point of shell, though still nearly terminal; this leaves a small anterior ear, best seen in internal fillings; a linear thickening occurs along the cardinal border; surface marked by strong, regular, equally distant, concentric lamellae. **Penn., Perm.**

A. americana Meek (**150**—10). Surface marked by two or three broad, faint, radiating ridges on the posterior dorsal region. **Penn.:** Ohio, Ia., Mo., Neb., Kan.

A. peracuta (Shumard) (**150**—8, 9). Shell almost cylindrical; cardinal edges of valves suddenly erected so as to give hinged margin a keeled appearance; differs from typical *Aviculopinna* in its weak lamellae. **Penn.:** Pa. and Ala. to Colo. and Ariz.; **Perm.:** Kan., N. Mex. (Gym).

PINNA Linnaeus 1758

(**P. rudis*). Shell equivalve, thin, with long hinge line; beaks very nearly or quite terminal; valves keeled, triangular, wholly open and truncate behind, without teeth; two muscle scars; shell structure coarsely prismatic, with a thin, partial, nacreous lining; byssiferous. **Jura.–Recent.**

P. laqueata Conrad (**150**—7). The type from the Owl Creek has 11 ribs. **U. Cret.:** Matawan and Monmouth of N. J. and Md.; Owl Creek of Miss.

PALAEOPINNA Hall 1883

(**P. flabella*). Differs from *Pinna* in having finer rays on surface of valves, convex umbos, and valves not keeled. **Dev.**

***P. flabella** Hall (**150**—12). **Dev.** (Oriskany): N. Y.

CONOCARDIUM Bronn 1834

(**C. hibernicum*). Very inequilateral; anterior side short, truncated and flattened laterally but produced along hinge line into beaklike appendage; this appendage, however, is usually broken away, leaving a round hole in the flat anterior view; posterior side extended and gaping in lateral view; beaks prominent and strongly incurved; hinge line long; umbonal ridge prominent, outlining the flat anterior side; surface marked by concentric striae and usually by radiating plications which crenulate the basal margin; hinge bearing a single lateral tooth, with occasionally an obscure cardinal tubercle; ligament external; pallial line simple; there is often present an expansion of the shell extending anteriorly from the entire periphery of the umbonal ridge. **Ord.–Perm.**

PLATE 152

[Figures are x1 unless otherwise indicated.]

1–10. Pteria spp. 1. P. sulcata [Kan G S 6; after Meek]. Left valve enlarged. **2. P. longa** [Kan G S 6]. Left valve. **3, 4. P. petrosa.** Exterior of right valve (x2) [USGS, PP 137] and filling of left valve [Pal N J 4]. **5. P. (Oxytoma) nebrascana** [USGS Ter 9]. Left valve of a large specimen. **6. P. linguaeformis** [USGS, PP 128]. Small left valve. **7. P. (Oxytoma) submeconnelli** [CGS, B 44]. Left valve of holotype (x0.6). **8. P. (Oxytoma) salinensis** [USGS, PP 131]. Left valve. **9. P. limula** [Md G S, Eoc]. Left valve (x2). **10. P. gastrodes** [USGS, B 106.] Large left valve (x0.7). **11, 12. Pteronites spp.** [Pal N Y 5]. Left valves of **P. rostratus** and **P. profundus** respectively. **13, 14. Caneyella richardsoni** [USGS, B 377]. Combined valves; right valve (x2). **15–21. Actinopteria spp. 15. A. auriculata** [Pal N Y 5]. Left valve. **16. A. communis** [N Y St Mus, M 3]. Left valve. **17. A. textilis** [N Y St Mus, B 92]. Right valve. **18. A. decussata** [Pal N Y 5]. Large right valve. **19, 20. A. boydi** [Pal N Y 5]. Left and right valves. **21. A. muricata** [Pal N Y 5]. Small left valve (x2). **22. Ptychopteria salamanca** [Pal N Y 5]. Left valve. **23–25. Pseudomonotis spp. 23. P. equistriata** [Kan G S 6]. Left valve of type. **24. P. hawni** [Kan G S 6]. Left valve. **25. P. curta** [U Kan Quart 9]. Left valve. **26, 27. Monopteria spp. 26. M. longispina** [Kan G S 6; after Keyes]. Left valve. **27. M. gibbosa** [Ind G S 13]. Right valve. **28. Daonella americana** [USGS, PP 83]. Adult shell (x1.5). **29. Monotis subcircularis** [Pal Cal 1]. Left valve.

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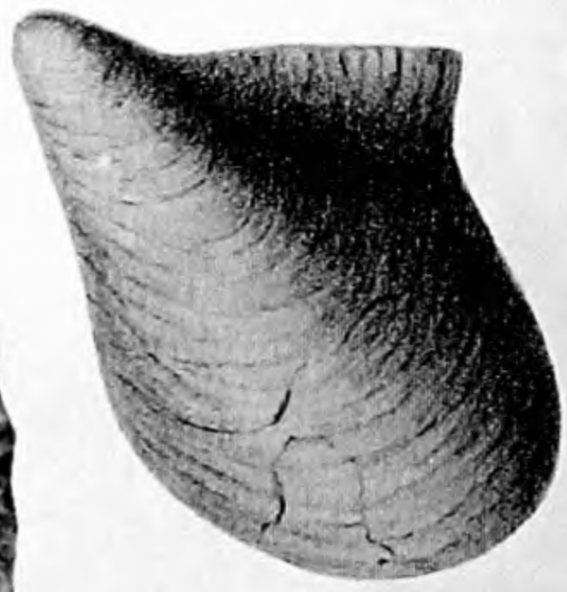

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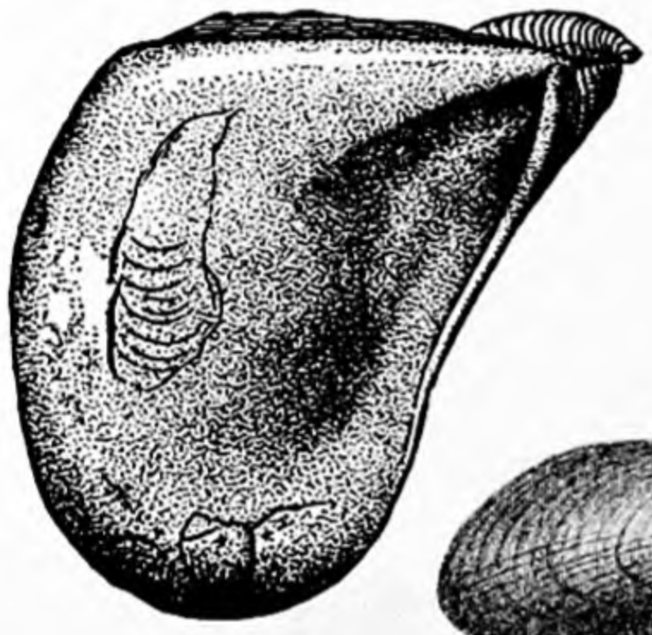

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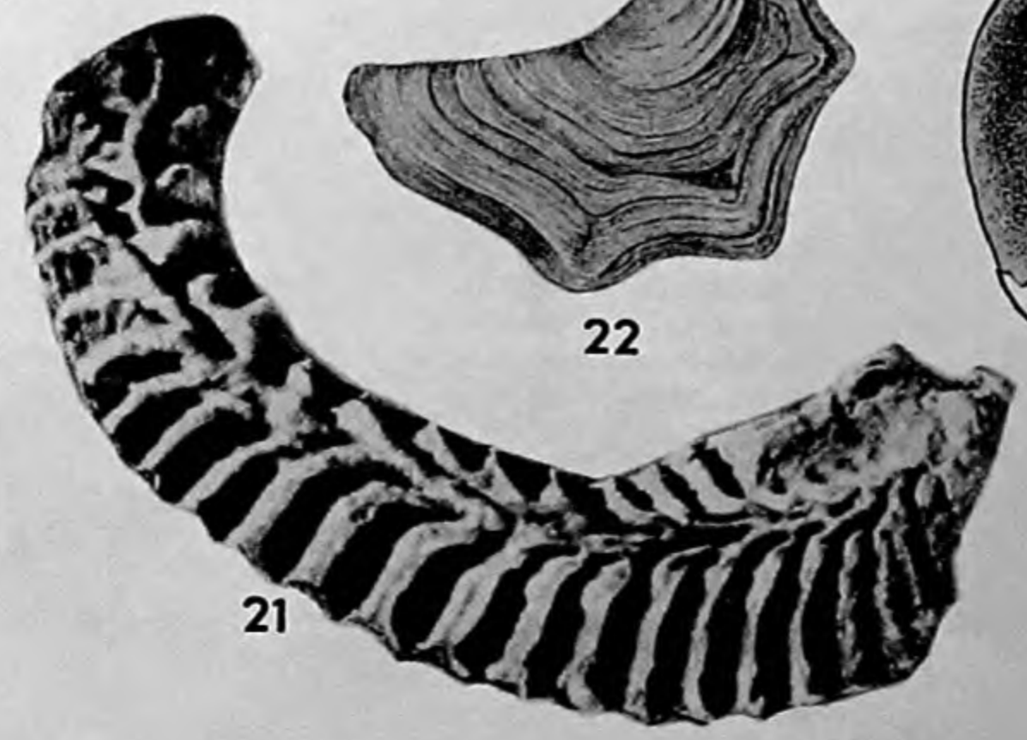

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C. cuneus (Conrad) (**150**—15–17; **151**—1). **Dev.** (Oriskany–Hamilton): Que.; N. Y. to Mich., south to Ky. and west to Ia. Characteristic of Onondaga.

C. ohioense Meek (**150**—18). Produced posterior extremity sharply separated from convex anterior; umbonal slope rounded. **Dev.** (Onondaga–Hamilton): Ont.; N. Y., Ohio, Ind., Ky., Wis.

BAKEWELLIA King 1848

(**Avicula antiqua* Münster). Small, obliquely elongated, with posterior wing, subequivalve, gaping in front for passage of byssus; umbos depressed, oblique; surface concentrically striated; hinge with linear anterior and posterior teeth parallel to cardinal margin; muscle scars as in *Pteris*; two to five transverse ligament pits in each valve. **Penn., Perm.**

B. parva Meek and Hayden (**150**—19). **Penn.:** Kan., Nev. **Perm.:** Kan., N. Mex., Ariz., Nev.

GERVILLIA Defrance 1820

(**G. solenoides*). Very inequivalve; beaks nearly or quite terminal; posterior wing obscure; hinge plate thick, marked by a series of transverse ligament pits, and by obscure dental ridges subparallel to long axis of valve; differs from *Bakewellia* in being larger and more elongate, usually with more cartilage pits, and especially differing in that the hinge teeth all range obliquely forward and upward instead of those on anterior and posterior sides being elongate parallel to hinge margin. **Jura.–Eoc.**

G. montanaensis Meek (**150**—11). **U. Jura.:** Mont.

G. propleura (Meek) (**150**—21). Right valve flat, smooth, without byssal notch. **U. Cret.** (Coloradoan): Ga. (Ripley), Colo. (Benton), Utah.

G. subtortuosa (Meek and Hayden) (**150**—20). **U. Cret.:** Mont. (Pierre).

GERVILLIOPSIS Whitfield 1885

(**Gervillia ensiformis* Conrad). Differs from *Gervillia* in its greater elongation and in lacking oblique dental ridges below the ligament area on posterior end; body of shell very oblique to hinge line. **Cret.**

***G. ensiformis** (Conrad). (**150**—13, 14). Very oblique, elongate, narrow, and somewhat sickle-shaped. **U. Cret.:** N. J. (Merchantville–Red Bank), Gulf Coastal Plain.

INOCERAMUS Sowerby 1814

(**I. cuvier*). Rounded, marked with more or less prominent concentric undulations; umbos prominent, somewhat anterior; hinge line long, straight, without teeth, but with numerous small, transverse ligament pits. **Jura., Cret.** (especially characteristic of **Cret.**).

I. comancheanus Cragin (**151**—11). **L. Cret.** (Washita): Kan., Okla., Tex., Colo., Wyo.

I. dimidius White (**151**—3, 4). **U. Cret.** (?, Benton): Kan., Colo., Utah, N. Mex.

I. simpsoni Meek (**151**—5). Large; beaks incurved, projecting but little above hinge line. **U. Cret.** (Coloradoan): S. Dak., Kan., N. Mex. Montanan: Sask., Alta. **U. Cret.:** San Luis Potosi, Mex.

I. fragilis Hall and Meek (**151**—6). **U. Cret.** (Benton and equivalents): Mont. and S. Dak. to Tex. (L. Eagle Ford) and N. Mex.

I. unabundus Meek and Hayden (**151**—9, 10). **U. Cret.** (Niobrara and equivalents): Alta.; Mont., Kan., Tex.

I. gilberti White (**151**—7, 8). **U. Cret.** (Niobrara): Kan., Utah, N. Mex.

I. (Volviceramus) umbonatus Meek and Hayden (**151**—13, 14). Large, very inequivalve; left valve very convex, beak obliquely involute forming one and one-half to two turns; right valve nearly flat. **U. Cret.** (Niobrara): Alta. to Tex. and N. Mex.

I. labiatus Schlotheim (**151**—15). **U. Cret.:** Coloradoan (M. Benton) throughout Great Plains and Rocky Mountain region. Worldwide in the Turonian.

I. deformis Meek (**151**—16). Often one of the depressions between the bounding undulations is much deeper than the others. **U. Cret.** (Niobrara): Great Plains and Rocky Mountain region.

I. undulato-plicatus Roemer (**151**—2). Shell inflated in umbonal region; several broad folds radiate from the midline to each side and terminate at undulate margin. **U. Cret.** (Austin and Niobrara): Widespread in Western Interior, in central Tex. (a narrow zone above middle of Austin), and northeastern Mex.

I. altus Meek. Differs from *I. fragilis* in being larger (15 cm high, hinge line 2.5 cm long), having more concentric undulations, though obscure, and faint traces of radiating markings. **U. Cret.** (Montanan): Kan., Wyo.; Alta.; **Coloradoan:** S. Dak.

I. barabina Morton (**151**—17, 18). **U. Cret.:** Ala., La., Great Plains and Rocky Mountain region (Montanan).

I. sagensis Owen (**151**—12). Surface with strong

PLATE 153

[Figures are x1 unless otherwise indicated.]

1. Daonella dubia [USGS, PP 83]. Adult shell. **2, 3. Halobia** spp. [USGS, PP 141]. **2. H. superba.** Right valve. **3. H. cordillerana.** Both valves. **4–10. Myalina** spp. **4. M. keokuk** [Ill G S 6]. Left valve. **5. M. perattenuata** [Kan G S 6]. Right valve. **6. M. illinoisensis** [USGS, B 593]. Left valve. **7. M. aviculoides** [USGS, B 77]. Impression of right interior. **8. M. subquadrata** [Ind G S 13]. Right valve (x0.5). **9. M. recurvirostris** [Ind G S 13]. Interior of left valve. **10. M. copei** [AMNH, B 16]. Exterior of right valve of type (x0.5). **11. Modiella pygmaea** [Pal N Y 5]. Right valve (x2). **12–16. Buchia** spp. **12. B. piochei** [Pal Cal 1]. Right valve. **13, 14. B. crassa.** Combined valves of a very convex specimen (x2) [Pal Cal 2]; left valve of a very large specimen [USGS, M 13]. **15, 16. B. terebratuloides** [USGS, B 133]. Right and side views. **17–25. Ostrea** spp. **17, 18. O. strigilecula.** Left valve [USGS, PP 152]; right valve [U Kan Quart 9]. **19. O. soleniscus** (x0.5) [USGS, An Rp 4]. **20. O. (Alectryonia) subovata** [Marcy: Expl Red River La, 1852]. Left (lower) valve. **21. O. (Alectryonia) carinata** [U Tex B 2838]. **22, 23. O. (Alectryonia) quadriplicata** [USGS, An Rp 4; 22 is Shumard's original figure]. Left and right valves. **24, 25. O. haydeni** [USGS, B 128]. Interior of lower valve and exterior of upper.

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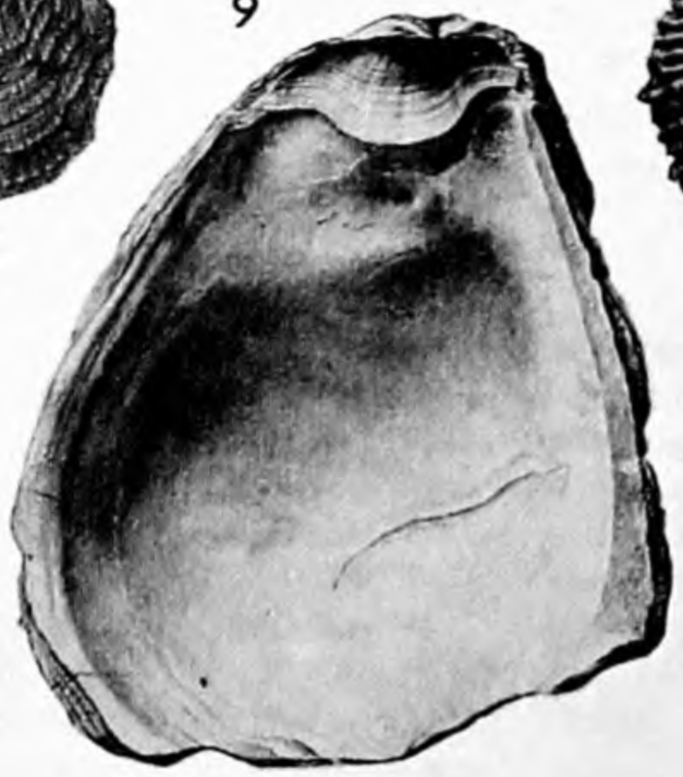

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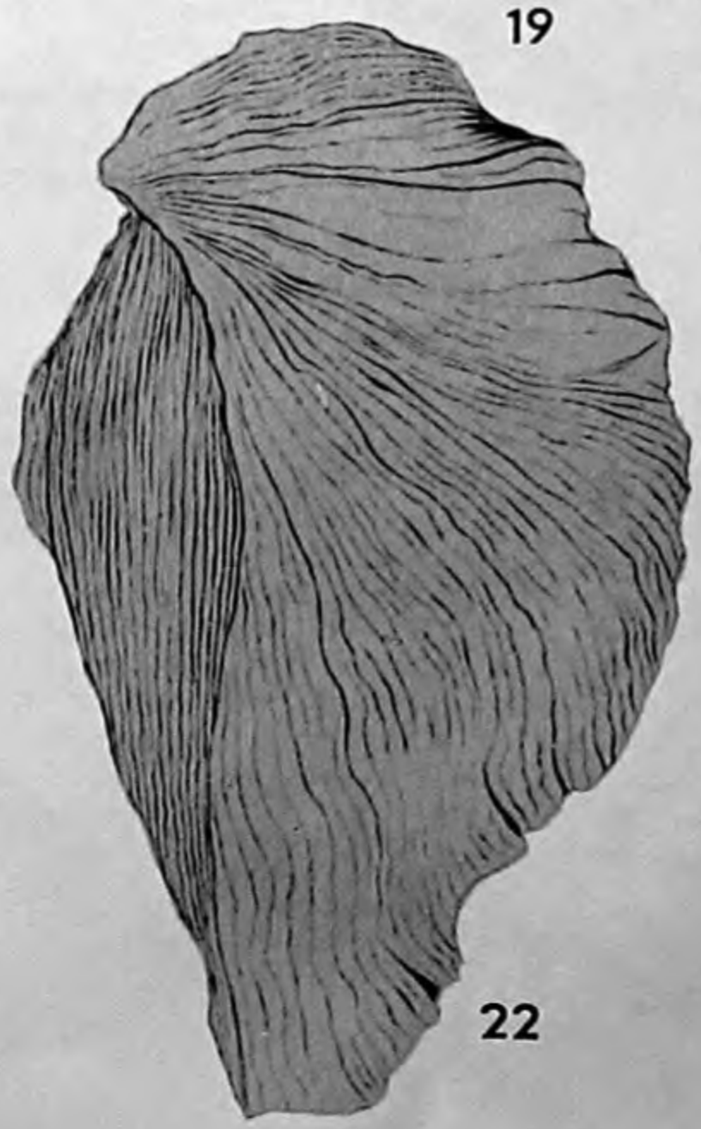

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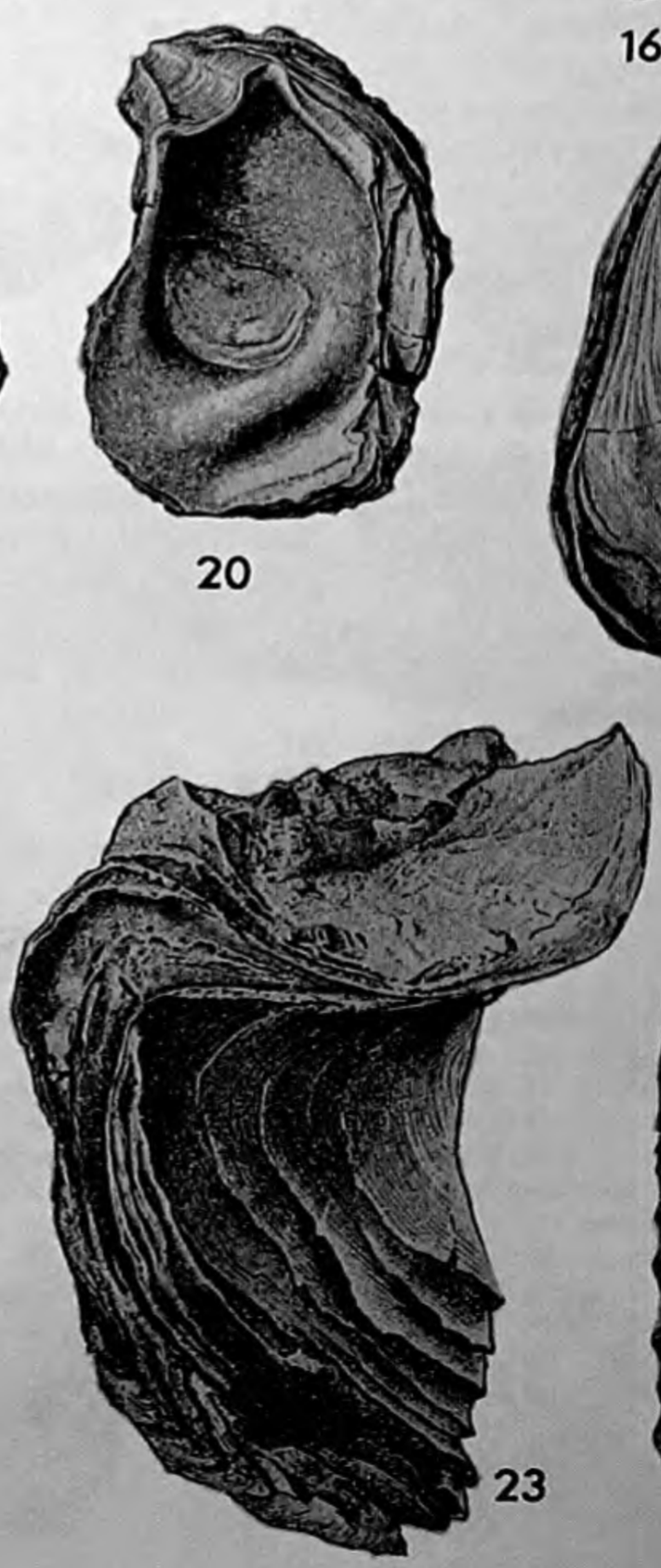

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concentric undulations, often with finer ones upon and between them. **U. Cret.:** Tenn. (Ripley); Sask. and Alta. to N. Mex. (Pierre).

PTERIA Scopoli 1777

(= AVICULA Bruguiere 1792)

(**Mytilus hirundo* Linnaeus). Obliquely oval, inequilateral, inequivalve; left valve more convex than right; hinge line long, straight, with obscure or obsolete teeth; posterior ear winglike, longer than anterior; byssal sinus present under right anterior ear; ligament in a groove, partly internal and partly external; posterior adductor scar large, subcentral; anterior scar absent in adults; sculpture not prominent; shell fragile. OXYTOMA Meek 1864 (**Avicula munsteri* Bronn) (**Trias.–Cret.**) has the right anterior ear defined beneath by a deep, sharply cut byssal sinus. **Dev.–Recent.**

P.? sulcata (Geinitz) (**152**—1). **Penn.:** Neb., Kan.

P.? longa (Geinitz) (**152**—2). **Penn.** of Central Interior. **Perm.:** Okla., Tex.

P. (Oxytoma) salinensis White (**152**—8). **Cret.** (Washita): Kan., Colo., Wyo., Tex.

P. (Oxytoma) submcconnelli McLearn (**152**—7). Shell bearing 14 radiating narrow ribs separated by finely striated interspaces. **M.? Jura.:** B. C.

P. petrosa (Conrad) (**152**—3, 4). **U. Cret.:** Questionably ranges through the *Exogyra ponderosa* and *E. costata* zones of the Atlantic and Gulf Coastal Plain.

P. linguaeformis (Evans and Shumard) (**152**—6). This western representative of *P. petrosa* appears to differ sufficiently from the eastern form to justify giving it species rank; distinguished by fact that the anterior ear is less distinctly separated from body of shell. **U. Cret.** (Montanan): Great Plains and Rocky Mountain region. Cal. (Chico).

P. gastrodes Meek (**152**—10). **U. Cret.** (Coloradoan): Kan., Colo., N. Mex., Utah.

P. (Oxytoma) nebrascana Evans and Shumard (**152**—5). **U. Cret.** (Montanan): Great Plains and Rocky Mountain region.

P. limula (Conrad) (**152**—9). Beaks acute; sinus of posterior ear not deep. **Eoc.:** Md. and Va. (Pamunkey), Ga. (Claiborne, Jackson).

PTERONITES McCoy 1842

(**P. angustatus* McCoy). Body very oblique; hinge line longer than body of shell; wing and hinge line extended posteriorly; shell surface marked by concentric striae. **Dev., Miss.**

P. rostratus Hall (**152**—11). **Dev.** (Canadaway): N. Y.

P. profundus Hall (**152**—12). **Dev.** (Conneaut): N. Y.

CANEYELLA Girty 1909

(**C. richardsoni*). Differs from *Pteronites* in lacking strong, posterior extension of hinge line, in having an anterior gape, concentric undulations, and usually radial costae. **Miss.**

***C. richardsoni** Girty (**152**—13, 14). **U. Miss.** (Caney): Okla.

ACTINOPTERIA Hall 1883

(**A. decussata*). Inequivalve, oblique, thin; anterior muscle scar faint or absent; pallial line simple; differs from *Pterinea* in lacking a broad striated ligament area and strong cardinal and lateral teeth. **Sil., Dev.**

A. communis (Hall) (**152**—16). **Dev.** (Helderbergian): Me., N. Y. to Md., W. Va., Tenn., Miss.

A. textilis (Hall) (**152**—17). **Dev.** (Helderbergian): N. Y. to Md., Tenn., Miss. **Oriskany:** N. B.; N. Y., N. J.

The variety *arenaria* Hall, which is distinguished from *A. textilis* by its greater size and shorter posterior wing, which extends only about one-half the distance from beak to base, occurs commonly in the **Oriskany** of Que., Ont.; N. Y. to Md., and W. Va.

A. muricata Hall (**152**—21). **Dev.** (Marcellus): N. Y. to Va.

***A. decussata** Hall (**152**—18). Left valve with numerous sharp radii. **Dev.** (Hamilton): N. Y. to Md., Ala.

A. boydi (Conrad) (**152**—19, 20). Ear and wing less defined and body of shell less oblique than in *A. decussata*. **Dev.** (Hamilton): Ont.; N. Y., Pa., Ind., Wis. **Portage:** N. Y., Md.

A. auriculata Hall (**152**—15). **Dev.** (Chemung): Pa.

PTYCHOPTERIA Hall 1883

(**P.? salamanca*). Differs from *Actinopteria* in the nasute anterior extremity and large straight wing marked by a strong longitudinal fold; surface with fine undulating rays. **Dev.**

***P. salamanca** Hall (**152**—22). **Dev.** (Conewango): N. Y.

MONOPTERIA Meek and Worthen 1866

(**Gervillia longispina* Cox). Shell aviculoid; without

PLATE 154

[Figures are x1 unless otherwise indicated.]

1–25. Ostrea spp. 1, 2. O. congesta [USGS, B 106]. Interior of upper valve; group of attached lower valves. **3. O. panda** [Pal N J 4]. Left (lower) valve. **4, 5. O. lugubris** [USGS, B 106]. Lower valve (Conrad's type specimen) and upper valves. **6, 7. O. cretacea** [NCGS 5]. Left exterior and interior of type. **8, 9. O. elegantula** [USGS, PP 186]. Left valve; right valve (x2). **10, 11. O. (Alectryonia) falcata** [USGS, PP 137]. Right and left valves. **12, 13. O. tecticosta.** Left valve [USGS, PP 137]; double valves from right side (x2) [Md G S, U Cret]. **14, 15. O. subspatulata** [NCGS 5]. Exterior and interior of right valve. **16. O. mesenterica** [Md G S, U Cret]. Left exterior (x4). **17, 18. O. plumosa** [NCGS 5]. Right exterior and interior. **19, 20. O. trigonalis** (x0.3), [Md G S, Mioc]. Exterior and interior of lower valve. **21, 22. O. titan** (x0.3) [U S Pacific RR Rp 6]. Right valve with left behind (holotype); side view. **23. O. sellaeformis** [Md G S, Eoc]. Lateral view (x0.7). **24, 25. O. glabra** [USGS, An Rp 4]. Upper and side views (x0.5).

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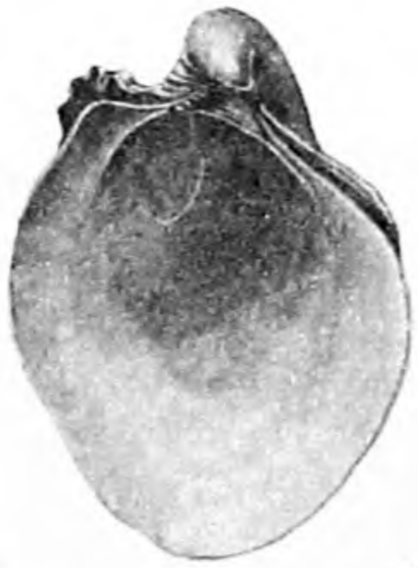

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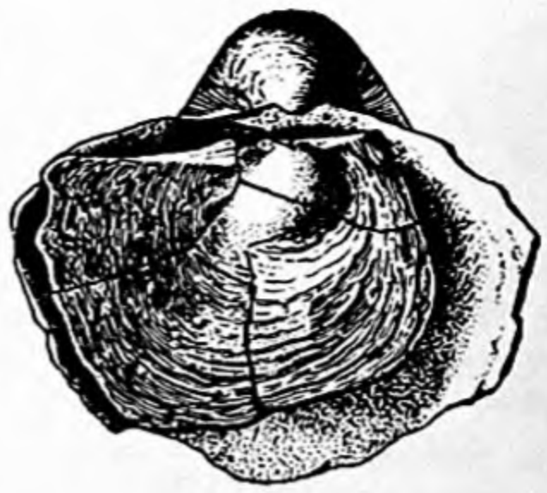

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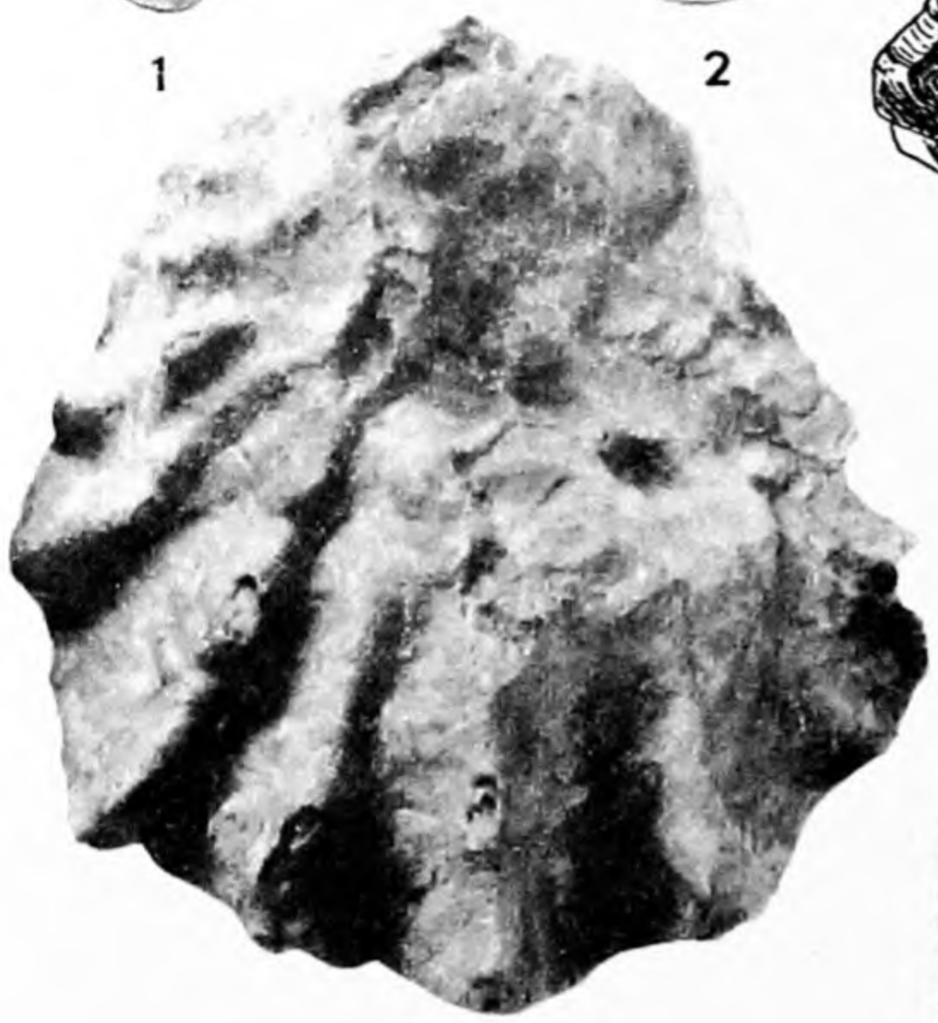

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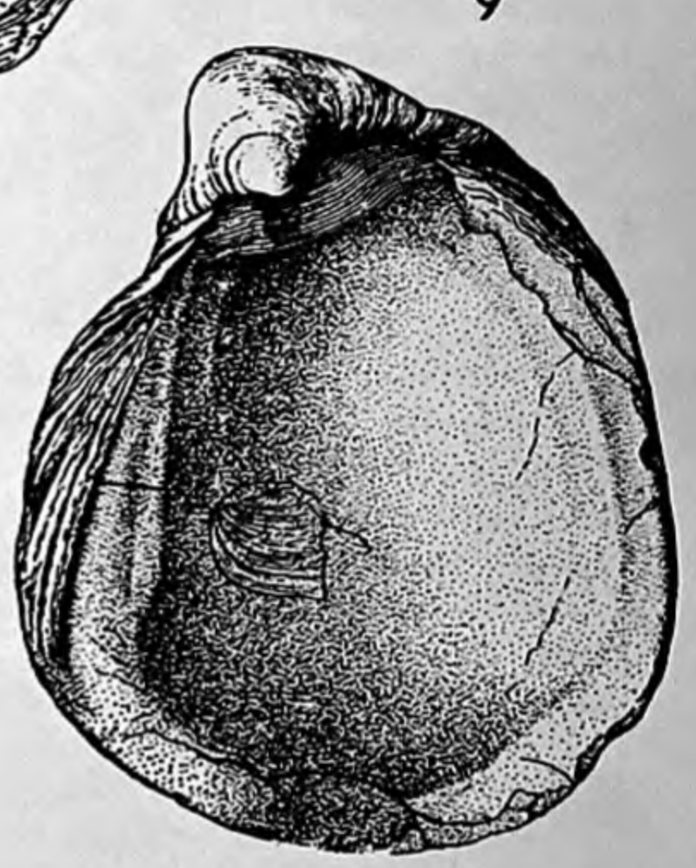

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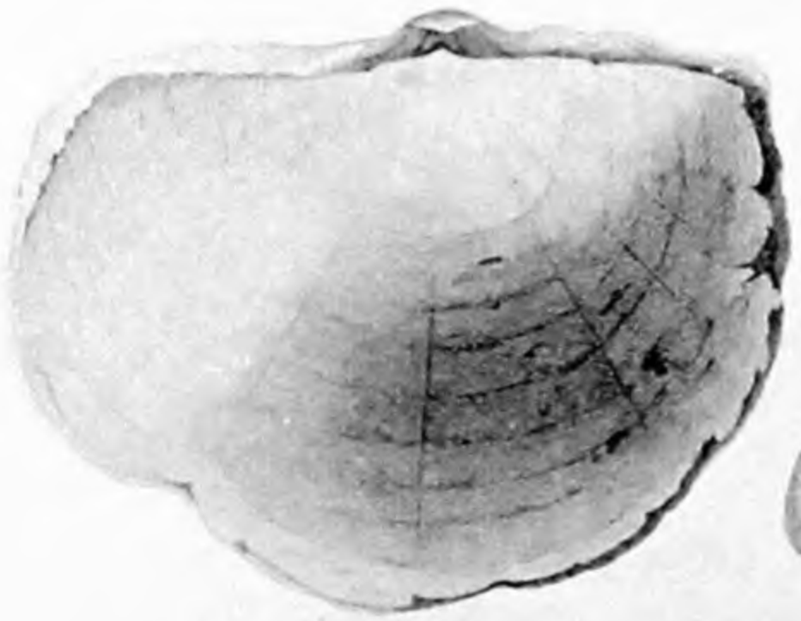

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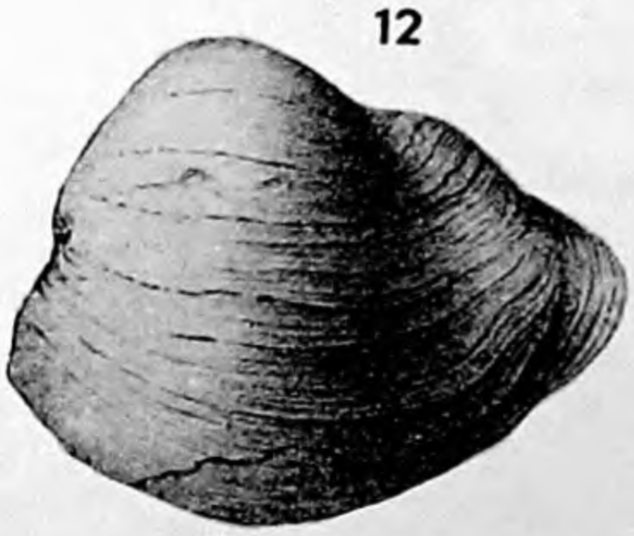

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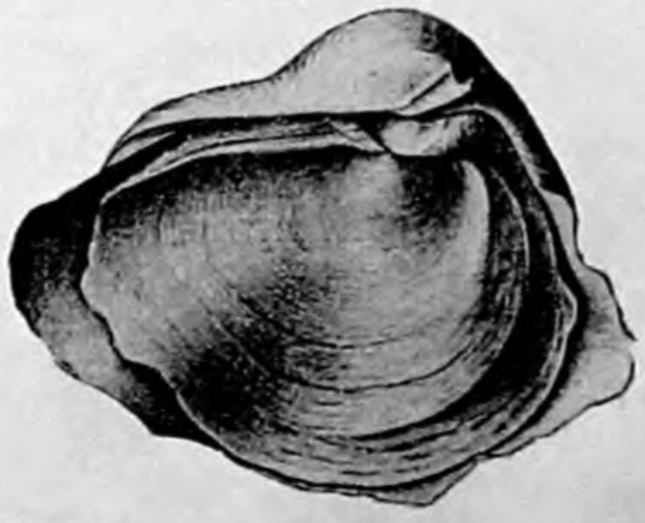

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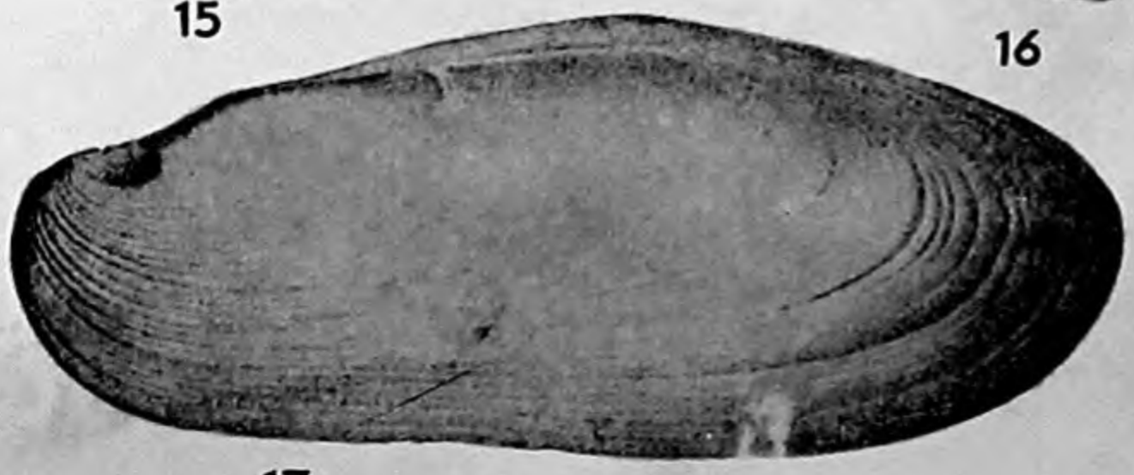

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teeth; anterior ear represented by a very small appendage drawn back between the beaks in a deep lunule not seen in side view; posterior wing slender, produced; body of shell obliquely produced and angular posteriorly. **Penn.**

***M. longispina** (Cox) (**152**—26). **Penn.:** Ky. to Colo.

M. gibbosa Meek and Worthen (**152**—27). **Penn.:** Pa. to Kan.

PSEUDOMONOTIS Beyrich 1862

(**Gryphites speluncaria* Schlotheim). Inequivalve, both valves with radial ribs or striae; the left valve arched, the right flat, attached at umbo throughout life; both ears weak but distinct; byssal notch in right valve; strong radial ribs or striae present. **Penn., Perm.; Mesozoic?**

P. equistriata Beede (**152**—23). **Penn.:** Kan., Mo., Okla., Tex.; **Perm.:** Kan. (Florence), Colo. (Rico).

P. (***Eumicrotis**) **hawni** (Meek and Hayden) (**152**—24). **L. Perm.:** Kan. (Big Blue).

P.? curta (Hall) (**152**—25). **U. Jura.** (Sundance): S. Dak., Wyo., Idaho (Twin Creek), Utah.

MONOTIS Bronn 1830

(**M. salinaria*). Equivalve, radially striate, with low subcentral beaks; anterior end rounded without wing; posterior wing short. **Trias.** (worldwide distribution).

M. subcircularis (Gabb) (**152**—29). **U. Trias.** (U. Noric): Nev., Alaska to Cal.; Colombia; Peru.

DAONELLA Mojsisovics 1874

(**D. moussoni*). Equivalve, semicircular to semioval, with straight hinge line, and small, pointed, almost central beaks; teeth absent; surface radiately ribbed; wings absent. **Trias.**

D. dubia Gabb (= **D. lommeli** of American authors) (**153**—1). **M. Trias.:** B. C.; Utah, Nev.

D. americana Smith (**152**—28). **M. Trias.:** Utah, Nev.

HALOBIA Bronn 1830

(**H. salinarum*). Differs from *Daonella* in having anterior ear separated from rest of shell by a groove; posterior ear weakly defined or absent; these two genera doubtless intergrade. **Trias.**

H. cordillerana Smith (**153**—3). Anterior ear with two strong radial ridges; surfaces of rest of shell marked by fine radiating dichotomous ribs which make a sharp bend forward in their course about 10 mm from the beak. **U. Trias.** (U. Karnic, Juvavites zone); Cal.; Alaska.

H. superba Mojsisovics (**153**—2). Differs from preceding in its coarser ribs and more oblique outline. Same distribution and range; also in **U. Trias.** of Alps and Himalayas.

MYALINA Koninck 1842

(**M. goldfussiana*). Inequilateral, inequivalve (right valve slightly smaller and less convex), obliquely ovate, slightly sinuous in front for passage of byssus; beaks pointed, terminal; surface smooth with concentric striae; hinge without teeth; ligament area broad and grooved parallel with hinge line; three small, deep muscle scars beneath umbo; posterior scar long and shallow, elongate parallel with posterior margin of shell; pallial line entire, represented by a series of small pits; marine. **Dev.–Perm.**

M. keokuk Worthen (**153**—4). **L. Miss.:** Colo. (U. Ouray), Ariz. (Escabrosa). **Keokuk:** Ind., Ill., Ia., Mo.

M. illinoisensis Worthen (= **M. arkansana** Weller) (**153**—6). **M.** and **U. Miss.:** Ill. (Meramec), Ark. (Batesville), Colo.

M. wyomingensis Lea (= **M. recurvirostris** Meek and Worthen) (**153**—9). Beak of left valve twisted. **Penn.:** Widespread from Pa. throughout the Mississippi Valley region.

M. subquadrata Shumard (**153**—8). Left valve more convex than right, which is nearly flat. **Penn.:** Tex., Colo., N. Mex., Ariz.

M. perattenuata Meek and Hayden (**153**—5). **Penn.:** Ill. to Colo.

M. aviculoides Meek and Hayden (**153**—7). **L. Perm.:** Kan., Wyo.

M. copei Whitfield (**153**—10). **L. Perm.:** Neb., Kan., Okla., Tex.

MODIELLA Hall 1883

(**Pterinea pygmaea* Conrad). Equivalve, inequilateral, with short anterior end (on anterior lobe) and very broad and curved posterior end; hinge line arcuate; surface covered with fine concentric striae and some faint curving radiating striae on body of shell; hinge area longitudinally grooved; pallial line simple. **Dev.**

***M. pygmaea** (Conrad) (**153**—11). Basal margin indented anterior to middle, owing to depression just anterior to beak and extending to base. **Dev.** (Hamilton–Naples): N. Y. to Md., W. Va.

BUCHIA Rouillier 1845
(= AUCELLA Keyserling 1846)

(**Avicula mosquensis* Buch). Obliquely ovate, with

PLATE 155

[Figures are x1 unless otherwise indicated.]

1–3. Ostrea spp. 1, 2. O. (Gryphaeostrea) vomer [Md G S, U Cret]. Left interior and right interior (x2). **3. O. vespertina** [San Diego Soc N H, Mem 1]. **4–7. Gryphaea spp.** [USGS, B 151]. **4, 5. G. navia. 6, 7. G. washitaensis. 8, 9. Anthracomya elongata** (x½, x2.5) [Dawson: Acadian Geology]. **10–12. Gryphaea spp. 10, 11. G. corrugata** [USGS, B 151]. Adult lower valves (x0.7). **12. G. mutabilis** [Ac N Sc Phila, J 6]. Right valve of holotype (x0.5). **13, 14. Nyassa arguta** [Pal N Y 5]. Right and left valves. **15, 16. Gryphaea convexa** [Pal N J 1]. Exterior and upper side of a specimen (x0.7). **17. Amnigenia catskillensis** [Pal N Y 5]. Right side (x0.7). **18. Naiadites carbonarius** [Dawson: Acadian Geology]. Left valve. **19–21. Gryphaea spp. 19. G. newberryi** [USGS, B 106]. Upper side. **20, 21. G. wratheri** [USGS, PP 186]. Left and right valves of holotype.

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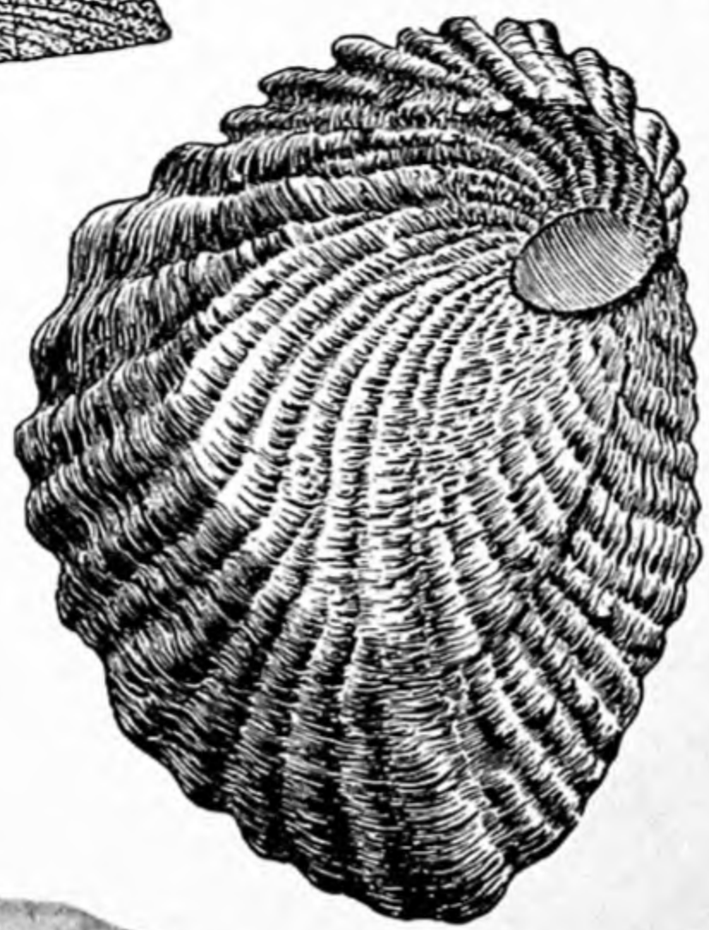

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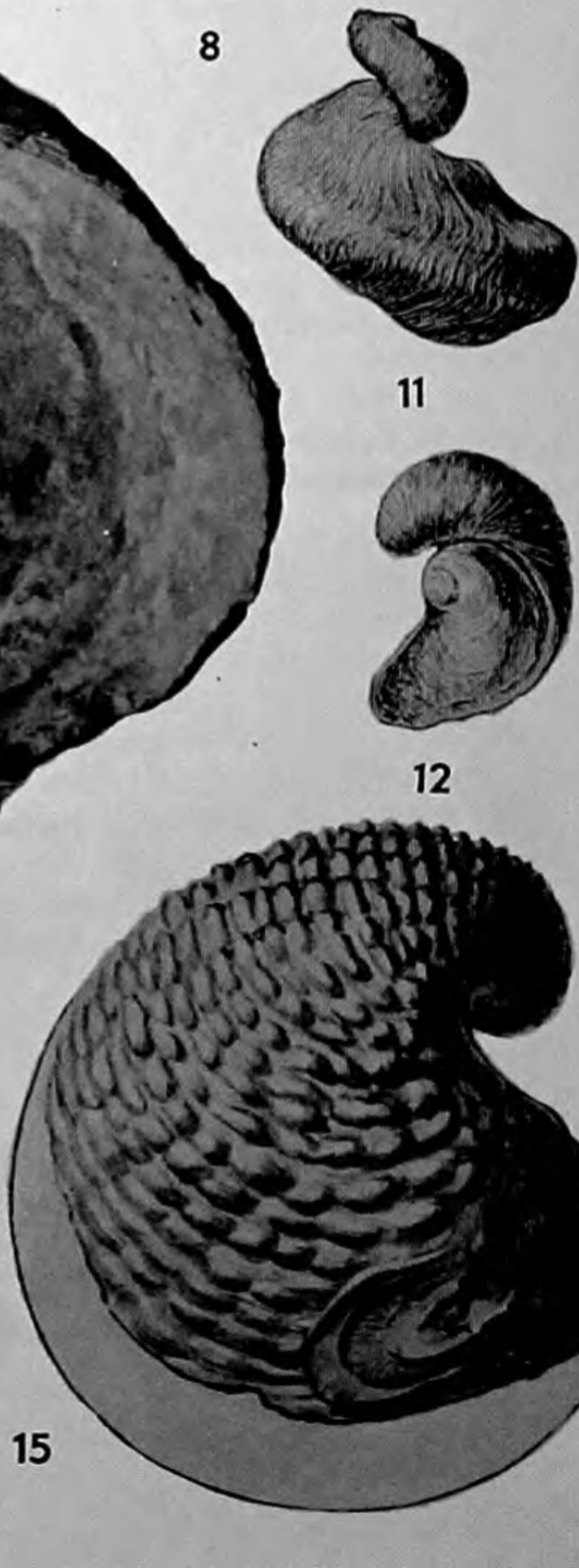

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anteriorly directed beaks; left valve larger and arcuate, with a small ear set off from the body of shell by a deep groove which extends from margin to beak; right valve flatter and smaller; hinge without teeth but furnished with an interlocking angle in right valve which fits into a corresponding notch in left; ligament external, in a long and shallow groove beneath the overhanging beaks; differs from *Inoceramus* in having sinus beneath beak and simple ligament groove as compared with the row of ligament pits in *Inoceramus*. **U. Jura., L. Cret.** (Arctic Islands; Greenland; western N. America; Siberia, and European Russia).

B. piochii (Gabb) (**153**—12). **U. Jura.:** Ore., Cal. (Knoxville); Russia.

B. crassa (Pavlon) (**153**—13, 14). **L. Cret.:** Very abundant in the Paskenta of Cal.

B. terebratuloides (Lahusen) (= **Aucella piochii** var. **ovata** in part) (**153**—15, 16). **L. Cret.:** Alaska to Cal. (Paskenta); Russia.

Superfamily OSTRACEA

OSTREA Linnaeus 1758

(**O. edulis*). Shell distorted by adherence to extraneous objects; structure lamellar; inequivalve, fixed by left or larger valve; beaks terminal; left valve convex, often marked by radiating ribs; right valve flat or concave, often smooth; sculpture usually different on the two valves; teeth generally absent; anterior muscle impression absent, posterior nearly central; ligament cavity conspicuous, triangular or elongate; pallial line distinct. The subgenus ALECTRYONIA Fischer 1807 (**Ostrea cristagalli* Linnaeus) is strongly plicate, giving a zigzag appearance to valve margins. **Trias.–Recent.**

O. strigilecula White (**153**—17, 18). **U. Jura.:** Throughout Western Interior region.

O. (Alectryonia) subovata Shumard (**153**—20). Surface coarsely imbricate and radially plicate; umbo angulated; height about 15 cm (6 in.). **L. Cret.** (Fredericksburg and Washita): Kan., Okla., Tex., N. Mex.

O. (Alectryonia) quadriplicata Shumard (**153**—22, 23). Four main radial plications, produced at valve margin. **L. Cret.** (Washita): Kan., Okla., Tex., Colo., N. Mex.; Mex.

O. (Alectryonia) carinata Lamarck (**153**—21). Shell with prominent carina. **L. Cret.:** abundant in Washita of Tex., less common in U. Fredericksburg.

O. soleniscus Meek (**153**—19). Variable but typically long and narrow; often very large and thick; beaks may be somewhat exogyroid. Lower half of **U. Cret.** in Colo., Tex. (Woodbine), Wyo., Utah.

O. haydeni White (**153**—24, 25). In brackish water. **U. Cret.** (Bear River): Wyo., Idaho.

O. panda Morton (**154**—3). Free margins of valves impressed with broad irregular plications which do not extend to the beak. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

O. congesta Conrad (**154**—1, 2). Lower valve cup-shaped, with large area of attachment around which shell margin abruptly bends up at right angle; upper valve flat, with form of attached portion of lower valve. **U. Cret.:** Characteristic of Niobrara and equivalents of N. America and occurs also in the Benton and Pierre; **U. Cret.** of Gulf Coastal Plain.

O. (Alectryonia) lugubris Conrad (**154**—4, 5). **U. Cret.:** Kan., Colo. (U. Benton), Tex. (U. Eagle Ford), N. Mex. (U. Benton); Mex.

O. elegantula White (**154**—8, 9). Shell thin, often translucent. **U. Cret.:** Ala. (L. Selma), Tex. (Blossom), N. Mex. (L. Mesaverde).

O. cretacea Morton (**154**—6, 7). Irregularly ovate, nonplicate; lower valve moderately convex, upper nearly flat; surface marked with concentric undulations, 20 mm high, width slightly more. **U. Cret.** (Lower part of *Exogyra ponderosa* zone): Ala., Ga. (Tombigbee in wells in N. C. and S. C.).

O. subspatulata Forbes (**154**—14, 15). **U. Cret.** (*Exogyra costata* zone): N. C. (Peedee); Ripley of Ga., Ala., Miss.

O. (Alectryonia) falcata Morton (= **O. larva**, in part, of American authors) (**154**—10, 11). **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Abundant in Atlantic and Gulf Coastal Plain.

O. mesenterica Morton (**154**—16). Smaller than *O. falcata* and with nonplicate central area. **U. Cret.:** Mainly in *Exogyra costata* zone of Atlantic and Gulf Coastal Plain.

O. tecticosta Gabb (**154**—12, 13). Right valve marked only by growth lines. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

O. plumosa Morton (**154**—17, 18). Outline variable, usually with decided constriction in umbonal region, sometimes faintly plicate; upper valve marked with fine superficial radiating striae which diverge from a median line; concentric lamellae sharp on weathered specimens. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain. **Montanan** of Western Interior.

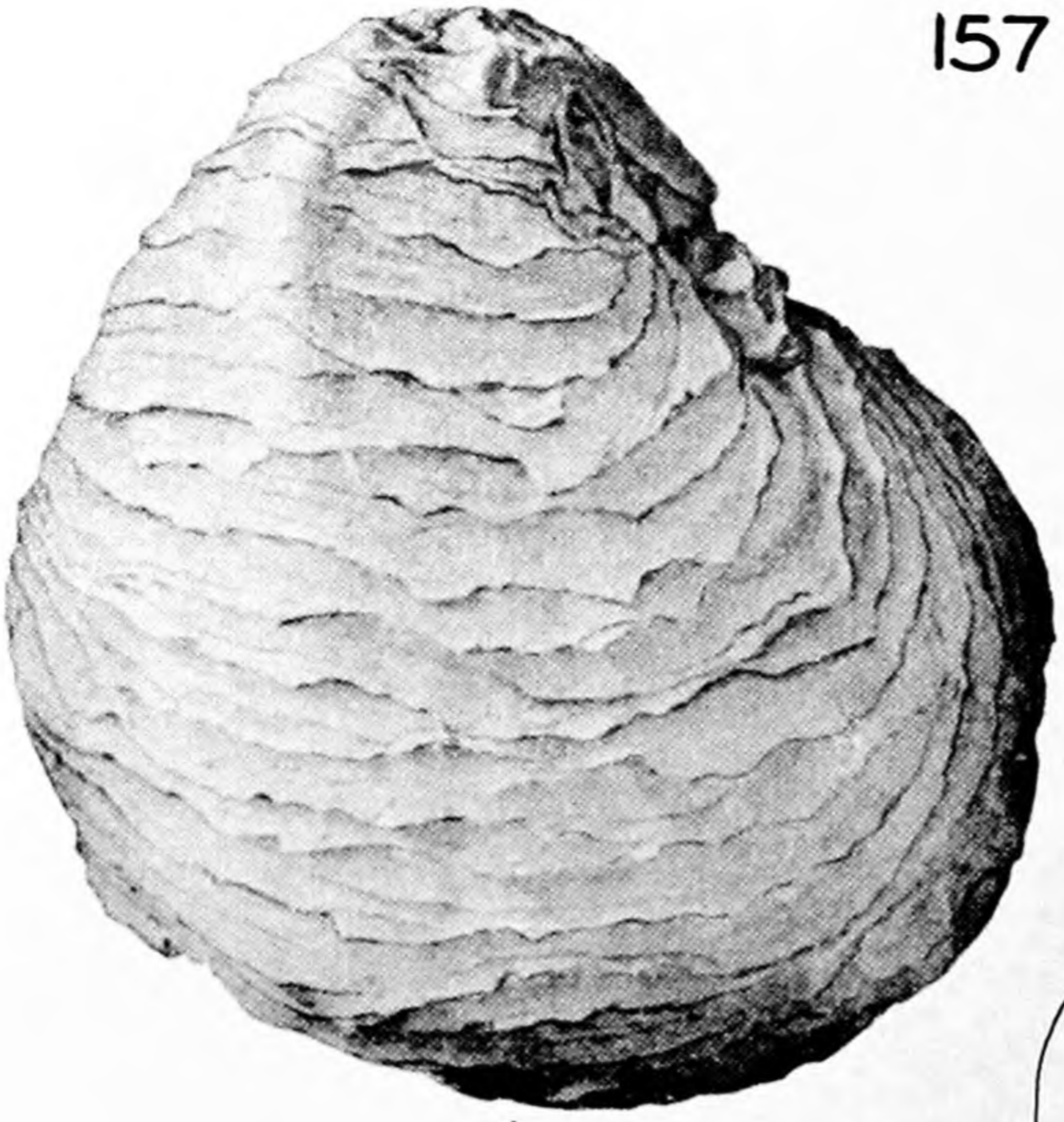
O. glabra Meek and Hayden (**154**—24, 25). Usually found with a brackish water fauna. **U. Cret.** (Montanan and Lance): Sask. and Alta. to Mex.

O. sellaeformis Conrad (**154**—23). Both valves deeply sinuous through vertical folding. **Eoc.:** Md. (Nanjemoy); Ala. to Tex. (Wilcox to Claiborne).

PLATE 156

[Figures are x1 and from USGS publications unless otherwise indicated.]

1–15. Exogyra spp. 1–3. E. columbella [B 106]. Side view of lower valve; upper view of a specimen with valves united; dorsal view of a large lower valve. **4, 5. E. laeviuscula** [PP 126]. A left valve. **6. E. olisipoensis oxyntas** [PP 154]. Left valve (x0.5). **7, 8. E. texana** [An Rp 4]. Opposite valves. **9, 10. E. ponderosa** [PP 126]. Left exterior and interior. **11, 12. E. arietina** [An Rp 4]. Two views of a specimen. **13, 14. E. costata** [An Rp 4]. Lower valve (x0.5). **15. E. cancellata** [Md G S, U Cret]. Left exterior.



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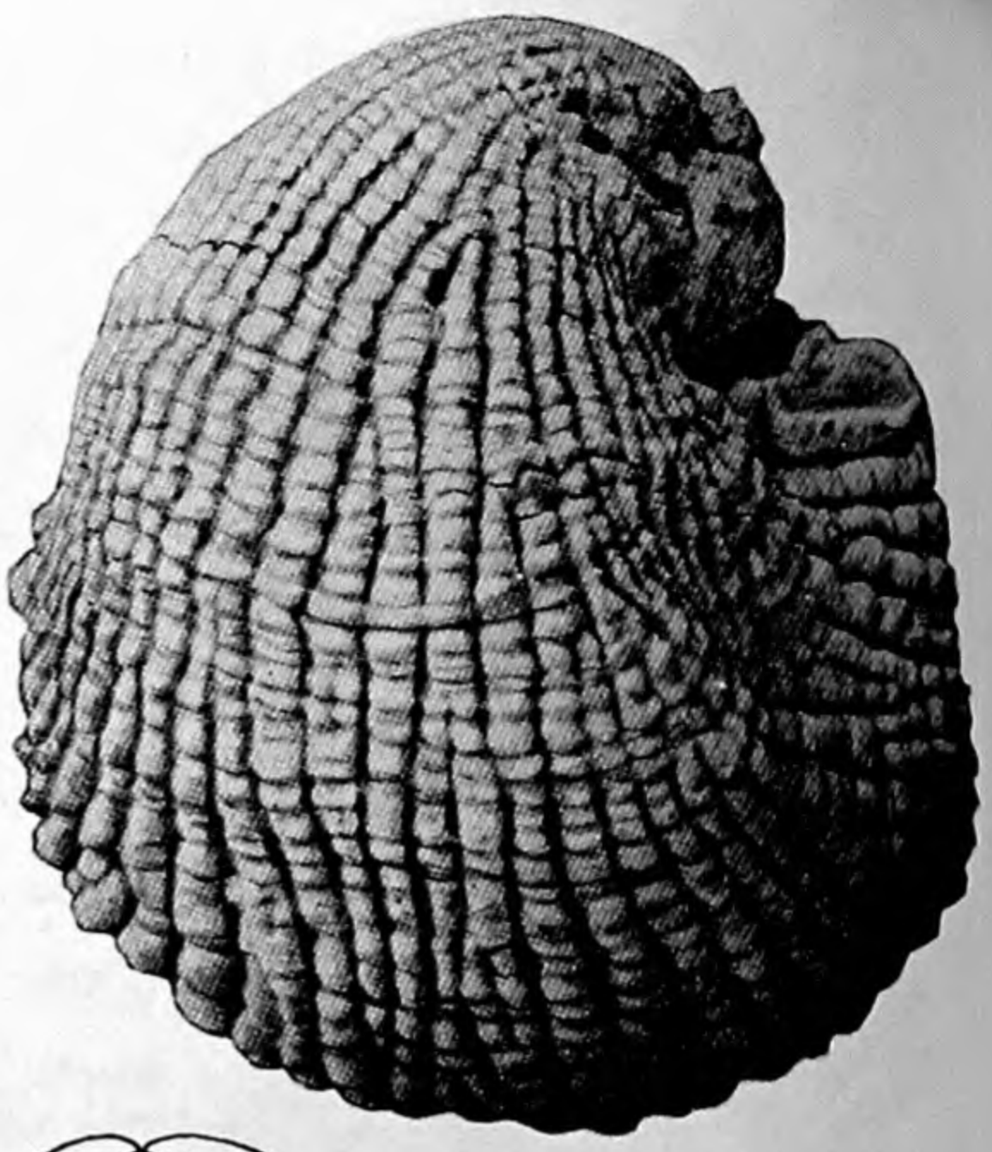

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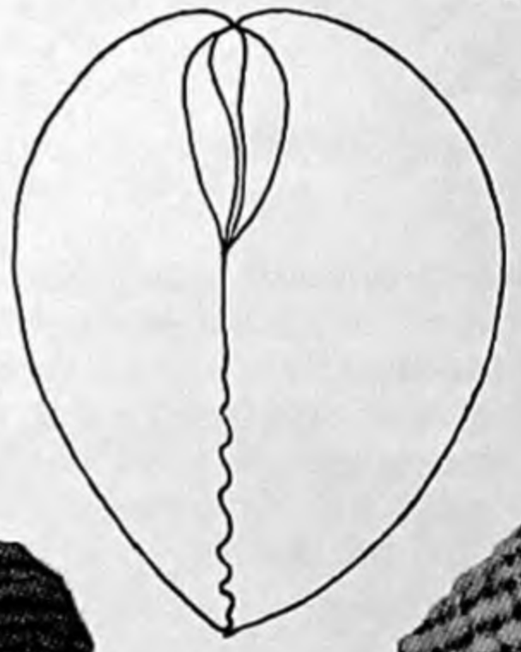

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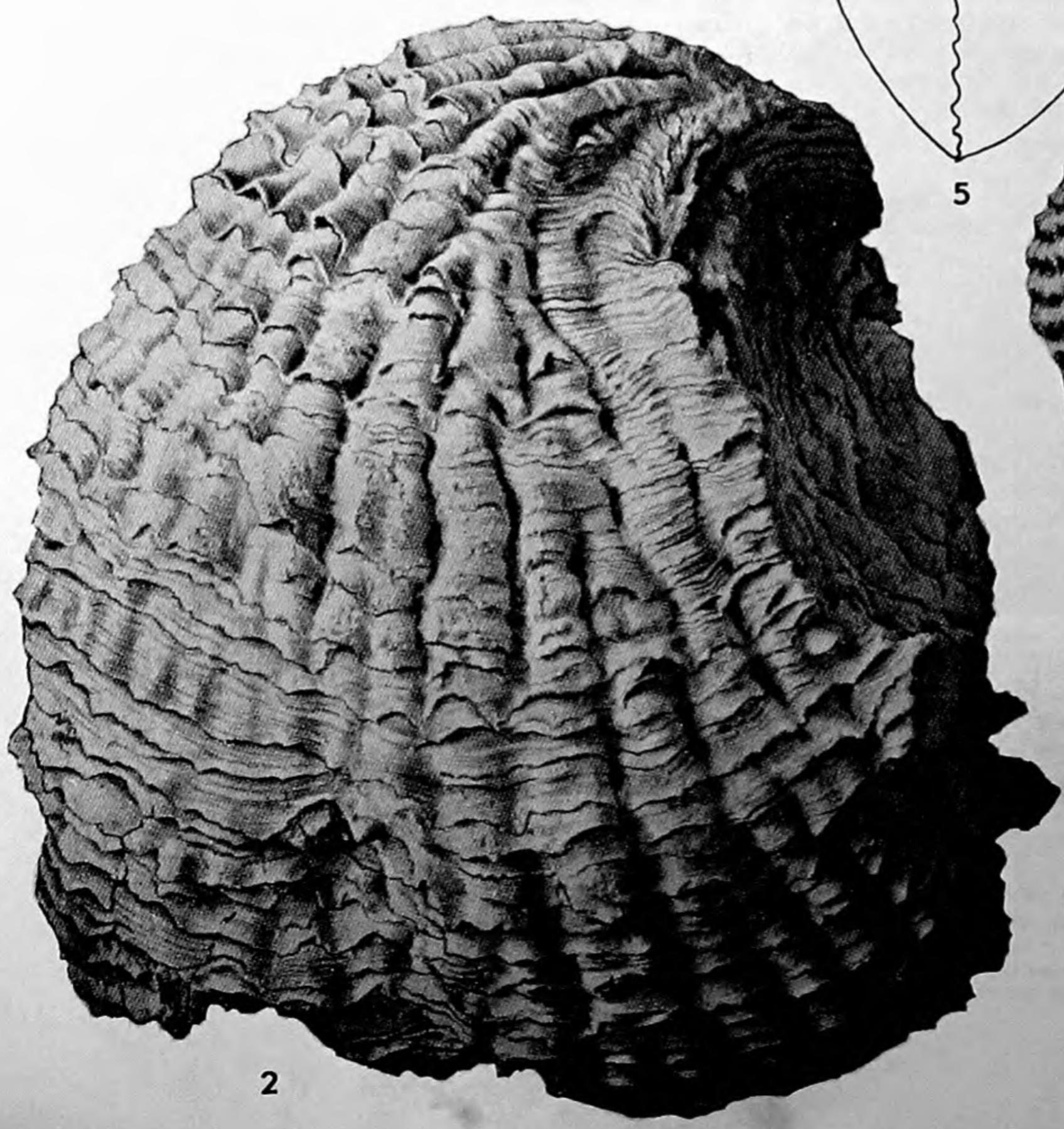

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O. trigonalis Conrad (**154**—19, 20). Lower valve few-ribbed; upper flat. **U. Eoc., Olig.:** Gulf Coastal Plain; **Mioc.:** Md. (Choptank), N. C.; **Plioc.:** Fla.

O. titan Conrad (**154**—21, 22). Large, up to 50 cm (20 in.) in length. **U. Mioc.:** Cal. (Neroly).

O. vespertina Conrad (**155**—3). Shell thick, with both valves plicate. **Mioc.:** Alaska to Cal.; **Plioc.:** Cal. to Mex.; **Pleist.:** L. Cal.; **Recent:** L. Cal. to Mex.

O. (*Gryphaeostrea) vomer (Morton) (**155**—1, 2). Attached left (lower) valve very convex with smooth surface; right (smaller) valve flattened; type of subgenus. **U. Cret.–Eoc.:** U. Matawan to Monmouth of N. J., Md.; U. Eutaw to Owl Creek and Prairie Bluff of Miss.; L. Selma to Prairie Bluff of Ala.; Selma of Tenn.; **Eoc.:** N. J. (Rancocas), Md. (Nanjemoy and Aquia), Ala. (Jackson).

GRYPHAEA Lamarck 1801

(**G. arcuata*). Sessile when young (attached in umbonal region of left valve), free when adult; left valve strongly arched, with beak incurved usually nearly in plane of median line and usually not much deflected to right or left; right valve flat and opercular, its beak inconspicuous and not deflected or coiled; surface usually marked only by concentric growth lines; muscle impressions as in *Ostrea*; less irregular than *Ostrea*, with beak of lower valve more produced and recurved; usually also lacks the strong radial plications often seen in *Ostrea* and *Exogyra*; differs from latter in that beak of lower valve curves upward instead of laterally; young often resemble shells of *Ostrea*. Some authors prefer PYCNODONTE Fischer 1835 (**P. radiata* = *Ostrea vesicularis* Lamarck) for the **U. Cret.** species. **Jura.–Eoc.;** chiefly **Mesozoic**.

G. corrugata Say (**155**—10, 11). **L. Cret.** (L. Washita): Southwestern N. America from Kan. into Mex.; especially common in the Kiamichi and Duck Creek of Tex. Three varieties have been recognized, distinguished mainly by differences in size. The small *G. corrugata hilli* Cragin, resembling the young of *G. corrugata*, is very abundant in Kan.; the large variety *tucumcarii* Marcou extends from Kan. to Tex. and N. Mex.; the large variety *belviderensis* Hill and Vaughan, differing from the preceding in its more triangular and flattened outline, extends from Kan. to Tex.

G. navia Hall (**155**—4, 5). Lower valve distinguished from *G. corrugata*, which it resembles in beak and surface characters, by its smaller size, the possession of a dorsal carina separated from the dorsal sinus by a depressed area which may be marked by slight ridges and by having a dorsal wing, produced by the expansion of the valve at its margin. **L. Cret.** (L. Washita): Kan. into Mex.; exceedingly abundant in the Kiamichi of Okla. and Tex.

G. washitaensis Hill (**155**—6, 7). **L. Cret.** (Washita): Tex., usually occurring with *Ostrea carinata* in great sheets.

G. mutabilis Morton (= **G. vesicularis** (Lamarck) of many American authors) (**155**—12). Shell broadly expanded on each side of beak, both valves obliquely corrugated on each side of hinge; right valve slightly concave; left valve convex with prominent umbo. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

G. convexa (Say) (**155**—15, 16). Left valve with posterior ear set off by sinus. **U. Cret.** (mainly upper part of *Exogyra ponderosa* zone): Atlantic and Gulf Coastal Plain.

G. wratheri Stephenson (**155**—20, 21). Radial depression from beak backward and downward may be wanting. **U. Cret.:** Ala. (Tombigbee), Tex. (M. Austin).

G. newberryi Stanton (**155**—19). **U. Cret.** (L. Coloradoan): Colo., Tex., N. Mex., Utah, Ariz.

EXOGYRA Say 1820

(**E. costata*). Shell massive, attached by left (lower) valve, which is always much deeper than the flat right or upper one; beak of lower valve always turned strongly backward and usually more or less spiral; beak of upper inconspicuous but deflected or spiral. **Jura.–Cret.**

E. texana Roemer (**156**—7, 8). **L. Cret.:** Widely distributed in the southern U. S. A. and Mex.; ranges from M. Trinity to L. Washita; especially characteristic of the Fredericksburg groups.

E. arietina Roemer (**156**—11, 12). **L. Cret.** (U. Washita): Okla., Tex.; Mex.

E. columbella Meek (**156**—1–3). **U. Cret.** (lower part): Colo., Tex., N. Mex.

E. olisiponensis Sharpe (**156**—6). Differs from *E. costata* in having the costae narrow, the interspaces wide and concave, and the concentric lamellae conspicuous. **U. Cret.:** Utah (Mancos); Mex.; Western S. America; Europe; Northern Africa; Palestine.

E. laeviuscula Roemer (**156**—4, 5). **U. Cret.:** Kan. (Benton), Tex. (Austin), Utah (Benton).

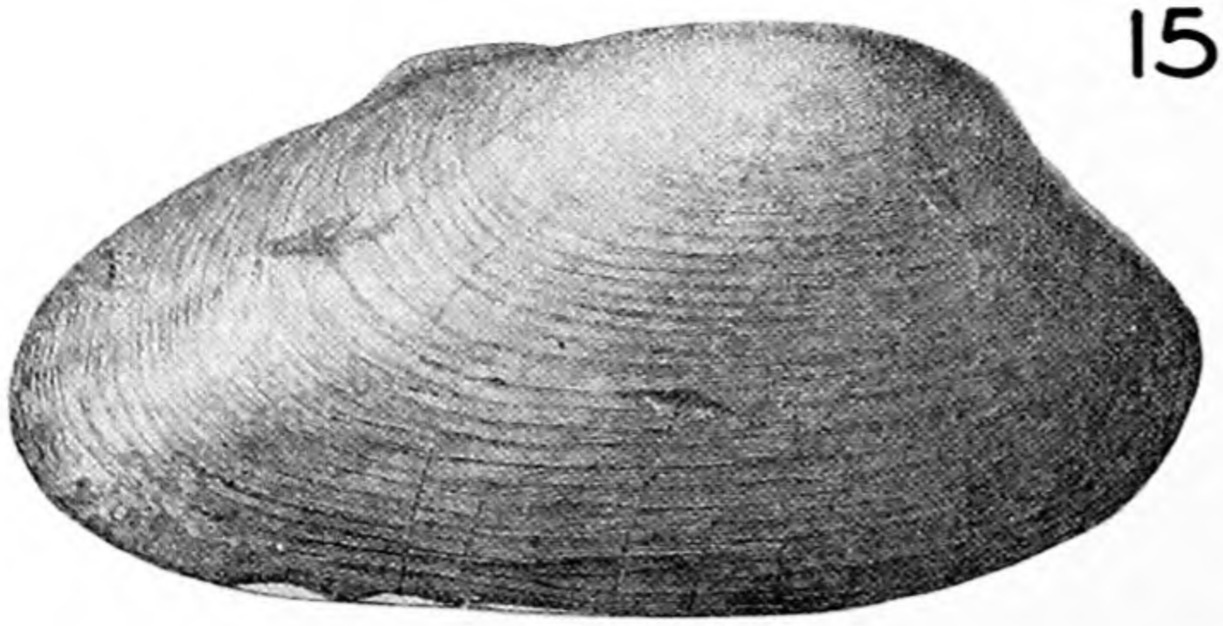
E. ponderosa Roemer (**156**—9, 10; **157**—1). Massive. **U. Cret.** (*Exogyra ponderosa* zone of Atlantic and Gulf Coastal Plain): Matawan, Black Creek, U. Tombigbee to M. Selma; also U. Austin to Taylor of Tex. and Mex.; Pierre of N. Mex.

***E. costata** Say (**156**—13, 14; **157**—2, 3). Differs from *E. ponderosa* in being strongly costate and in lacking lamellose extensions. **U. Cret.** (*E. costata* zone of Atlantic and Gulf Coastal Plain): Mon-

PLATE 157

[Figures are x1 and after Stephenson and Monroe [Miss G S, B 40] unless otherwise indicated.]

1–4. Exogyra spp. 1. E. ponderosa. 2, 3. E. costata. Valves with wide and narrow costae respectively. **4. E. cancellata.** The type. **5, 6. Pecten (Plagioctenium) circularis** [USGS, PP 47]. Profile of shell, viewed from rear, showing strong convexity of valves; right exterior.



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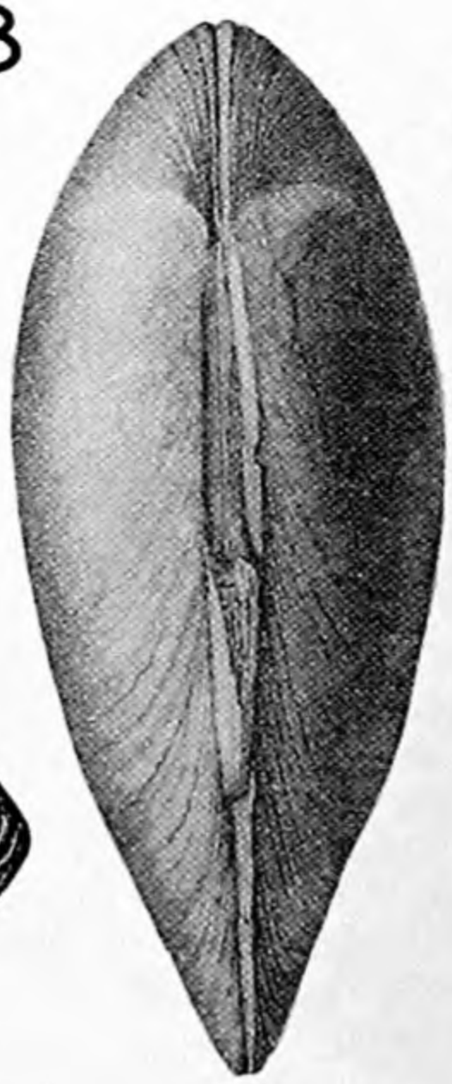

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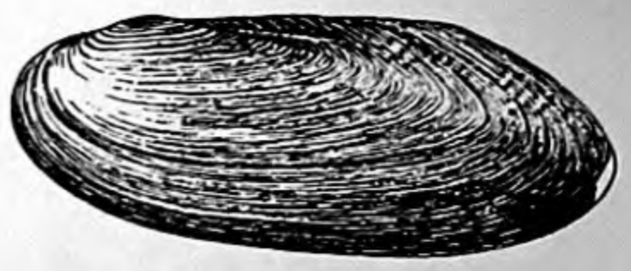

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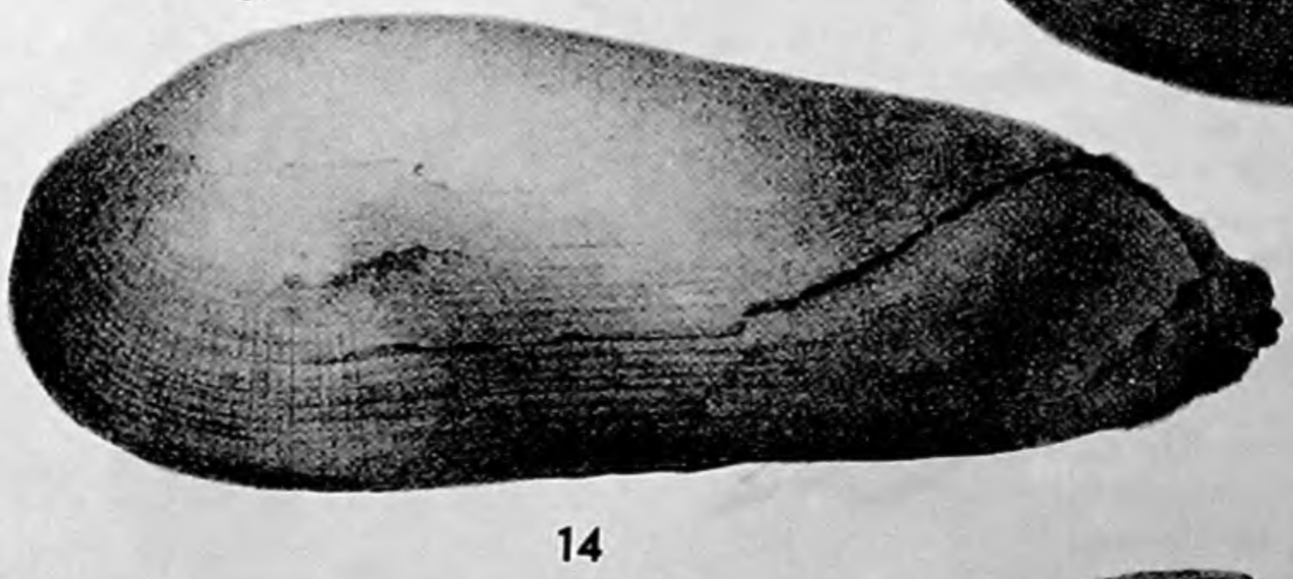

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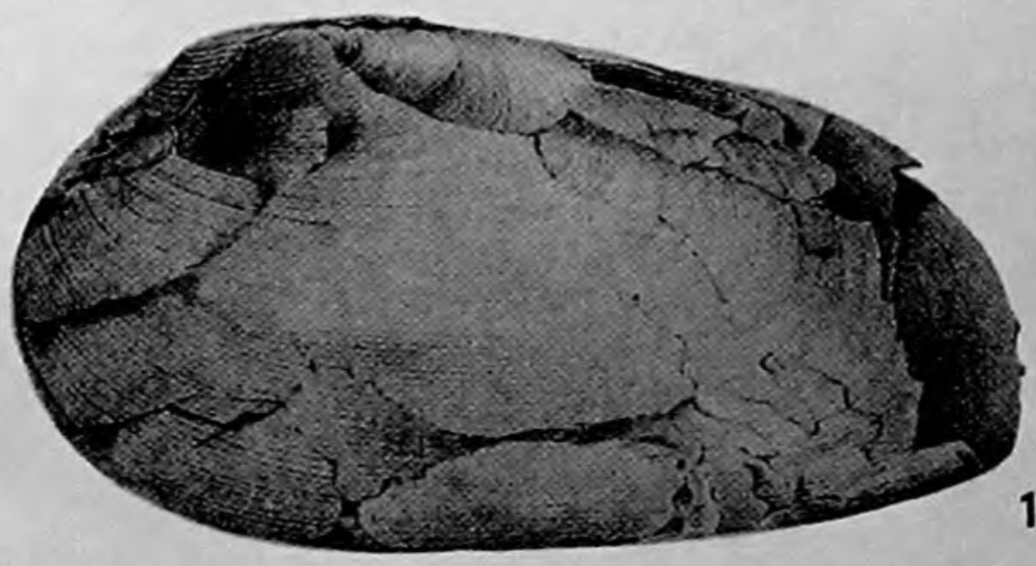

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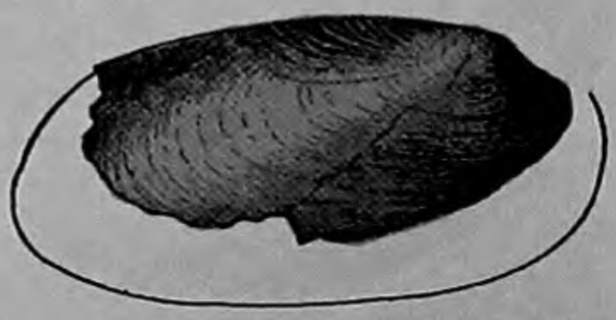

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mouth, Peedee, Ripley, U. Selma, Providence, Prairie Bluff, Owl Creek; Colo. (Pierre); Mex.

E. cancellata Stephenson (**156**—15; **157**—4). Differs from *E. costata* in its distinctive ornamentation. **U. Cret.** (*E. cancellata* zone): In lower part of zone containing *E. costata* of Atlantic and Gulf Coastal Plain; i.e., L. Monmouth, L. Navarro, and equivalents.

Superfamily NAIADACEA

AMNIGENIA Hall 1885

(**Cypricardites catskillensis* Vanuxem). Equivalve, very inequilateral, subelliptical, with very short anterior end and prolonged and wider posterior end; both extremities rounded; beaks low and appressed; hinge line long, gently arcuate; umbonal slope not defined; teeth obscure; hinge line marked by one or two longitudinal lateral folds; ligament external, extending more than halfway from beak to posterior end; pallial line simple; lived in fresh water. **Dev.**

***A. catskillensis** (Vanuxem) (**155**—17). **M.** and **U. Dev.** (Catskill facies): N. Y., Pa.

NAIADITES Dawson 1860

(**N. carbonarius*). Shell inequivalve; beaks not terminal (otherwise much like *Myalina*); surface devoid of radial ornamentation; hinge without well defined teeth; ligament area with fine longitudinal furrows; slightly sinuous in front for passage of byssus; pallial line entire, represented by a series of small pits; brackish or fresh water. **Penn.**

***N. carbonarius** Dawson (**155**—18). Shell usually much distorted by pressure. **Penn.:** N. S. and Cape Breton.

ANTHRACOMYA Salter 1861

(**Naiadites elongata* Dawson). Differs from *Naiadites* in having posterior end produced, expanded, and usually truncate; hinge with narrow internal ridge parallel with edge of valve in its posterior portion; hinge plate not striated; an oblique diagonal ridge passes from umbo downward and backward; differs also in being inequivalve, with larger and more conspicuous umbos; byssal notch absent; fresh or brackish water dwellers. **Penn.**

***A. elongata** (Dawson) (**155**—8, 9). **Penn.:** N. S. and Cape Breton; Ohio, Ala., N. Mex.; Great Britain.

NYASSA Hall 1869

(**N. arguta*). Beaks small, anterior; hinge line long, arcuate; oblique median depression and umbonal ridge often present; surface concentrically striated; hinge with several irregular and coalescing teeth anteriorly and with one to four elongate lateral teeth posteriorly; ligament external and inconspicuous; pallial line simple. **Dev.**

***N. arguta** Hall (**155**—13, 14). **Dev.** (Marcellus—basal Hamilton): N. Y.

UNIO Retzius 1788

(**U. margaritiferus* Linnaeus). Epidermis thin; umbos anterior; surface smooth, concentrically striated, corrugated or rarely spinose; hinge line with heavy, amorphous, radial, pseudocardinal and lateral teeth; ligament external; pallial line simple; fresh water dwellers. **Trias.–Recent.**

U. (Antediplodon) dockumensis Simpson (**158**—3). Umbo prominent, with distinct radiating lines. **U. Trias.** (Dockum): Tex.

U. felchi White (**158**—1, 2). **U. Jura.** (Morrison): Colo.

U. (Lampsilis) farri Stanton (**158**—4). **L. Cret.** (Kootenai): Mont.

U. (Elliptio) douglassi Stanton (**158**—5, 6). **L. Cret.** (Kootenai): Mont.

U. (Elliptio) hamili McLearn (**158**—7, 8). **L. Cret.:** Alta (Blairmore).

U. dowlingi McLearn (**158**—9). **U. Cret.** (Coloradoan): Alta. (Dunvegan).

U. subspatulatus Meek and Hayden (**158**—10, 11), **U. Cret.** (Judith River and Belly River): Assiniboia, Mont.

U. danae Meek and Hayden (**158**—13, 14). Sides of valves concave from arched base; surface when slightly exfoliated with obscure radiating striae. **U. Cret.** (Judith River): Mont.

U. senectus White (**158**—19). Thin; cardinal and lateral teeth separated by a considerable space; posterior to line running from beak to posterior basal angle the surface has numerous small crenulated undulations. **U. Cret.:** Belly River, Judith River, Edmonton of Sask. to Mont.

U. (Proparreysia) holmesianus White (**158**—17, 18). Strong medial sinus present; umbo strongly sculptured. **U. Cret.** (Lance, Fruitland): Mont. to N. Mex.

U. (Elliptio) priscus priscus Meek and Hayden (**158**—15, 16). **Paleoc.** (Fort Union): S. D., Mont., Wyo.

U. shoshonensis White (**158**—12). **Eoc.:** Wyo., Colo.

Superfamily TRIGONIACEA

LYRODESMA Conrad 1841

(**L. planum*). Moderately convex, equivalve, in-

PLATE 158

[Figures are x1 unless otherwise indicated.]

1–19. Unio spp. 1, 2. U. felchi [USGS, B 29]. Right valve and dorsal view of type. **3. U. (Antediplodon) dockumensis** [USNM, Pr 18]. Right valve of a small specimen. **4. U. (Lampsilis) farri** [Am Phil Soc, Pr 42]. Right valve. **5, 6. U. (Elliptio) douglassi** [Am Phil Soc, Pr 42]. Left valve and dorsal view. **7, 8. U. (Elliptio) hamili** [Nat Mus Can, B 85]. Dorsal view of paratype; left valve of holotype. **9. U. dowlingi** [CGS, Mus B 29]. Both valves of holotype. **10, 11. U. subspatulatus** [USGS Ter 9]. Dorsal and left valve views of type. **12. U. shoshonensis** [USGS, An Rp 12]. Left valve. **13, 14. U. danae** [USGS Ter 9]. Dorsal and left valve views of type. **15, 16. U. (Elliptio) priscus** [USGS Ter 9]. Left valve of type; right valve of a young specimen. **17, 18. U. (Proparreysia) holmesianus** [USGS, An Rp 12]. Left valve and cardinal views (x0.5). **19. U. senectus** [USGS, An Rp 3]. Right valve (x0.5).

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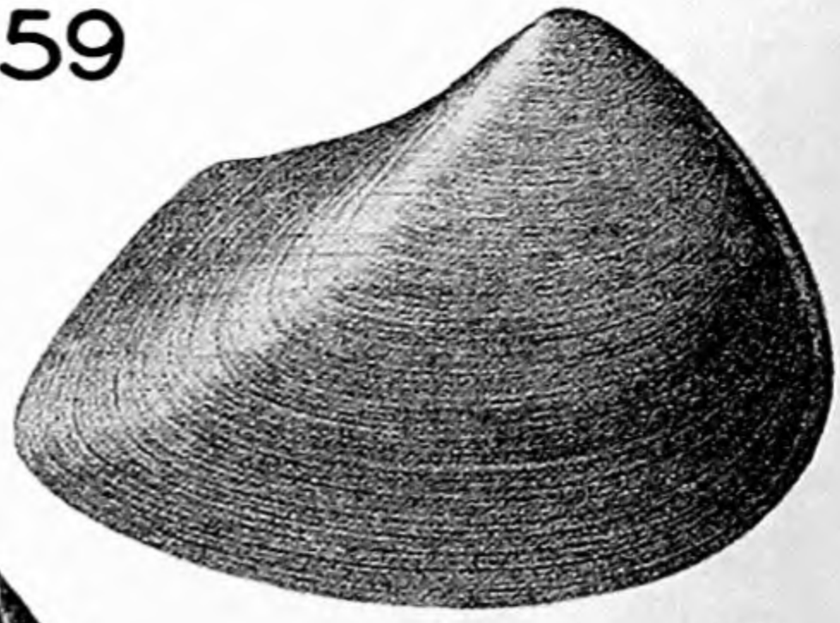

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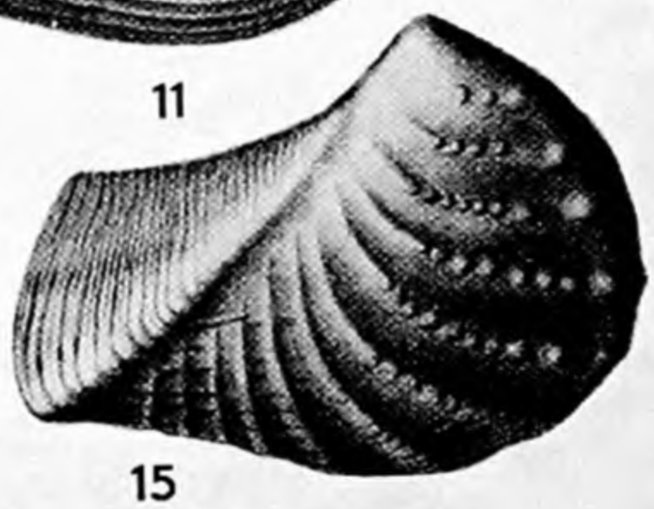

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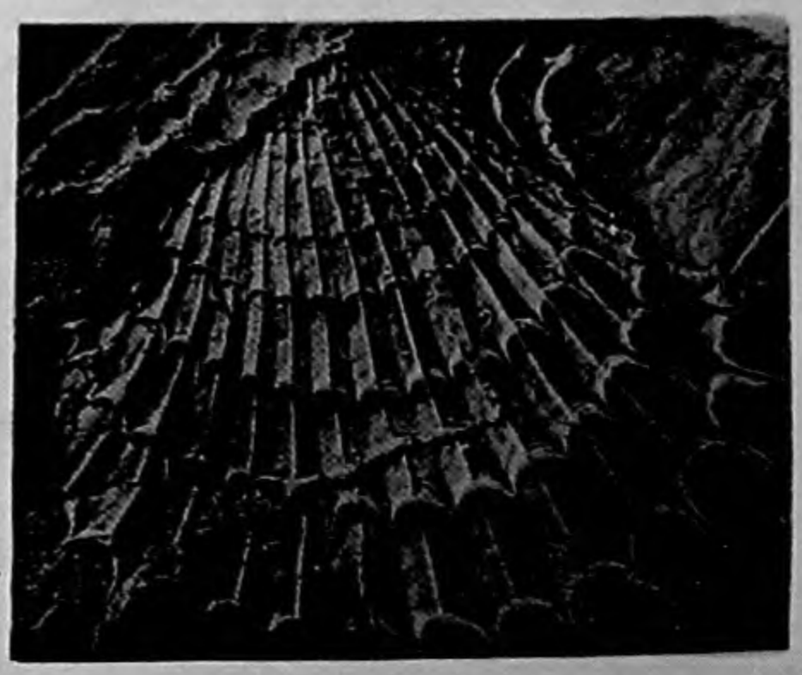

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equilateral; beaks small, anterior to middle; posterior umbonal slope usually prominent; surface concentrically striated; hinge with six to eight prominent, subequal, transversely striated teeth radiating regularly from the beak and placed on a thick plate; posterior adductor scar larger than anterior; pallial line slightly sinuate posteriorly; no ligament area present. **Ord., Sil.**

L. major (Ulrich) (**159**—6, 7). Hinge with six teeth. **U. Ord.:** Cincinnati region (Maysville), Ohio and Minn. (Richmond).

SCHIZODUS King 1844

(**S. schlotheimi* Geinitz). Shell thin, trigonal, often tending toward quadrate, longest posteriorly; right valve with two smooth cardinal teeth, left with three; surface smooth or concentrically striated; two muscle impressions, anterior one with small radial buttress; pallial line simple. **Dev.–Perm.**

S. chemungensis (Conrad)(**159**—2). **Dev.** (Ithaca–Conewango): N. Y. to Md.

S. cuneatus Meek (**159**—3). **Penn.:** Pa. to Colo.

S. wheeleri Swallow (**159**—1, 4). **Penn.:** Pa. to N. Mex. **Perm.:** Kan.

MYOPHORIA Bronn 1834

(**M. vulgaris* Schlotheim). Shell trigonal, smooth or radially sculptured, with a strong radial ridge extending backward from the umbos to basal margin; sculpture on areas thus separated is usually discrepant; two cardinal teeth in each valve; muscle scars buttressed by feeble ridges. **Trias.**

M. alta Gabb (**159**—5). **U. Trias.:** Cal., Nev.

TRIGONIA Bruguière 1789

(**Venus* or *Donax sulcata* Hermann [controversial]). Thick, trigonal, very inequilateral, with rounded anterior and produced and angular posterior margin; generally marked by a ridge extending from the umbos to posterior border, cutting off dorsal area which has different ornamentation; beaks nearly terminal anteriorly, directed posteriorly; surface bearing rows of tubercles or radiating or concentric ribs; two large cardinal teeth in right valve, three in left; teeth striated; ligament external; pallial line simple. **Jura.–Recent.**

T. quadrangularis Hall and Whitfield (**159**—9). Surface with two sets of ridges making an acute angle with each other. **Jura.:** Dakotas and Wyo. (Sundance), Idaho, Utah.

T. americana Meek (**159**—11). **U. Jura.:** Mont. (Ellis), Utah.

T. montanaensis Meek (**159**—15). **U. Jura.:** Mont. (Ellis), Utah.

T. vyschetzki Cragin (**159**—8). **U. Jura.:** Tex. (Malone); Mex.

T. emoryi Conrad (**159**—14). Ribs change direction in passing over posterior dorsal area and again over escutcheon. **L. Cret.** (Fredericksburg and Washita): Okla., Tex., N. Mex. (Purgatoire); Sonora, Mex.

T. evansana Meek (**159**—10). **U. Cret.** (Chico): Vancouver Island (Nanaimo); Ore., Cal.

T. eufaulensis Gabb (**159**—12, 13). Ribs angular, 12 to 14. **U. Cret.:** N. C. (Peedee), Ala. (Ripley), Miss. (Ripley and Owl Creek).

Section D. ISODONTA

Superfamily PECTINACEA

AVICULOPECTEN McCoy 1851

(**A. planoradiatus* McCoy). Pectiniform, inequilateral, inequivalve, with right valve usually less convex than left; hinge line straight with both anterior and posterior ears; surface usually radially sculptured; a single oblique, subcentral resilifer beneath each beak; teeth absent; pallial line simple. **Sil.–Perm.**

A. cleon Hall (**159**—16). **M. Dev.:** Ohio.

A. cancellatus (Hall) (**159**—17). **Dev.** (Naples?, Chemung–Canadaway): N. Y. to Md.

A. (***Annuliconcha**) **interlineatus** Meek and Worthen (**159**—18, 19). Subgenus characterized by its strong concentric growth ridges, the radii weak and interrupted. **Penn.:** Ohio to Neb. to Tex., Ariz.

A. (**Fasciculiconcha**) **providencesis** (Cox) (**159**—20). Subgenus characterized by having striae on the strong radii of the left valve and low simple radii on the right valve. **Penn.** (Des Moines): Ind., Ky., Mo., Kan., Okla., Tex.

A. occidentalis (Shumard) (**159**—21, 22). **U. Penn.:** Lower part of the Missouri Series of the Plains (Neb., Mo., etc.).

A. vanvleeti Beede (**159**—24). Rays prominent only when halfway down shell. **Perm.:** Okla. (Whitehorse).

A. girtyi Newell (**159**—23). Differs from *A. vanvleeti* in the extended posterior auricles and its more nearly subcircular form. **Perm.:** Tex. (Word) N. Mex. (Manzano).

PLATE 159

[Figures are x1 unless otherwise indicated.]

1–4. Schizodus spp. 1, 4. S. wheeleri [Ind G S 13]. Left exterior; filling of interior viewed dorsally. **2. S. chemungensis** [Pal N Y 5]. Left valve. **3. S. cuneatus** [Ohio G S 2]. Right valve. **5. Myophoria alta** [USGS, PP 141 from Pal Cal 1]. Right valve of type (x2). **6, 7. Lyrodesma major** [Minn G S 3 (2)]. Exterior and interior of two right valves. **8–15. Trigonia spp. 8. T. vyschetzki** [USGS, B 266]. Left valve (x0.5). **9. T. quadrangularis** [NAIF]. Impression of right interior. **10. T. evansana** [Pal Cal 1]. Right valve. **11. T. americana** [USGGS Ter 1878 (Hayden)]. Right valve. **12, 13. T. eufaulensis** [NCGS 5]. Dorsal and exterior views of left valve. **14. T. emoryi** [USGS, B 205]. Right valve. **15. T. montanaensis** [USGGS Ter 1878 (Hayden)]. Right valve. **16–24. Aviculopecten spp.** [16 and 17 from Pal N Y 5; 18–24 from Kan G S 10]. **16. A. cleon.** Left valve. **17. A. cancellatus.** Right valve. **18, 19. A. (Annuliconcha) interlineatus.** Left exterior and anterior views of holotype (x2). **20. A. (Fasciculiconcha) providencesis** [Ky G S 3]. Left valve (x0.5). **21, 22. A. occidentalis.** Right and left valves. **23. A. girtyi.** Left valve of holotype. **24. A. vanvleeti.** Left valve of a hypotype. **25–27. Acanthopecten spp.** [Kan G S 10]. **25. A. coloradoensis.** Exterior (x2) **26, 27. A. carboniferous.** Right valve (x3); exterior (x3).

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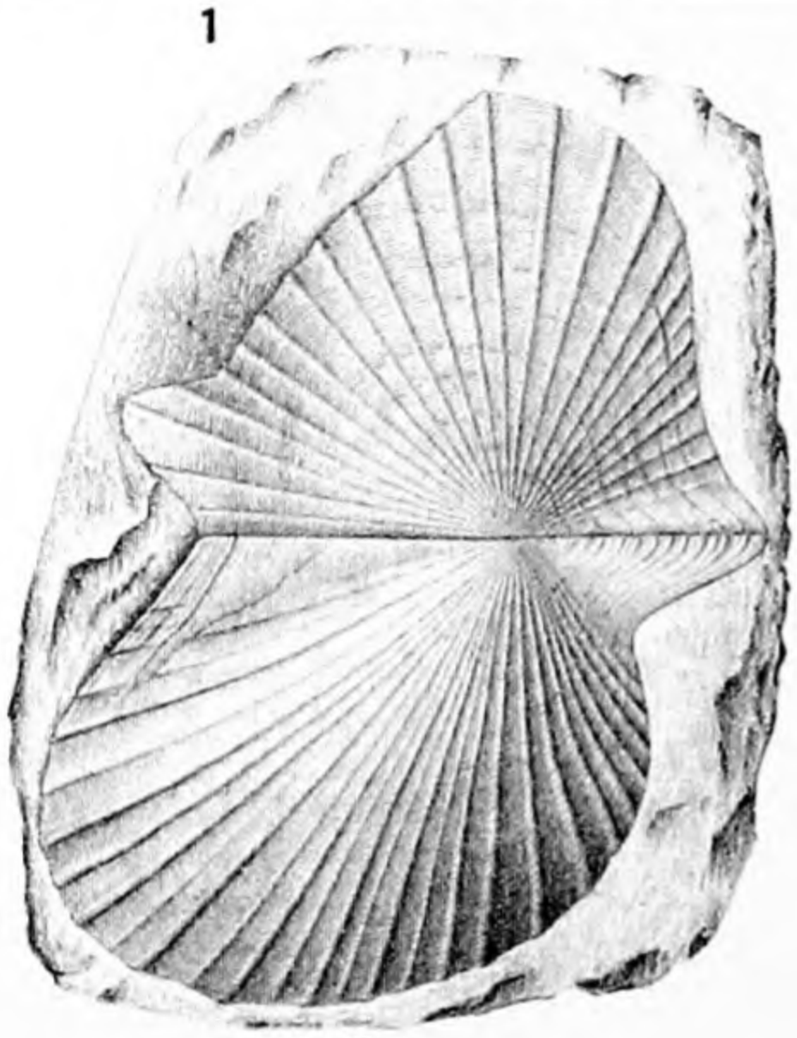

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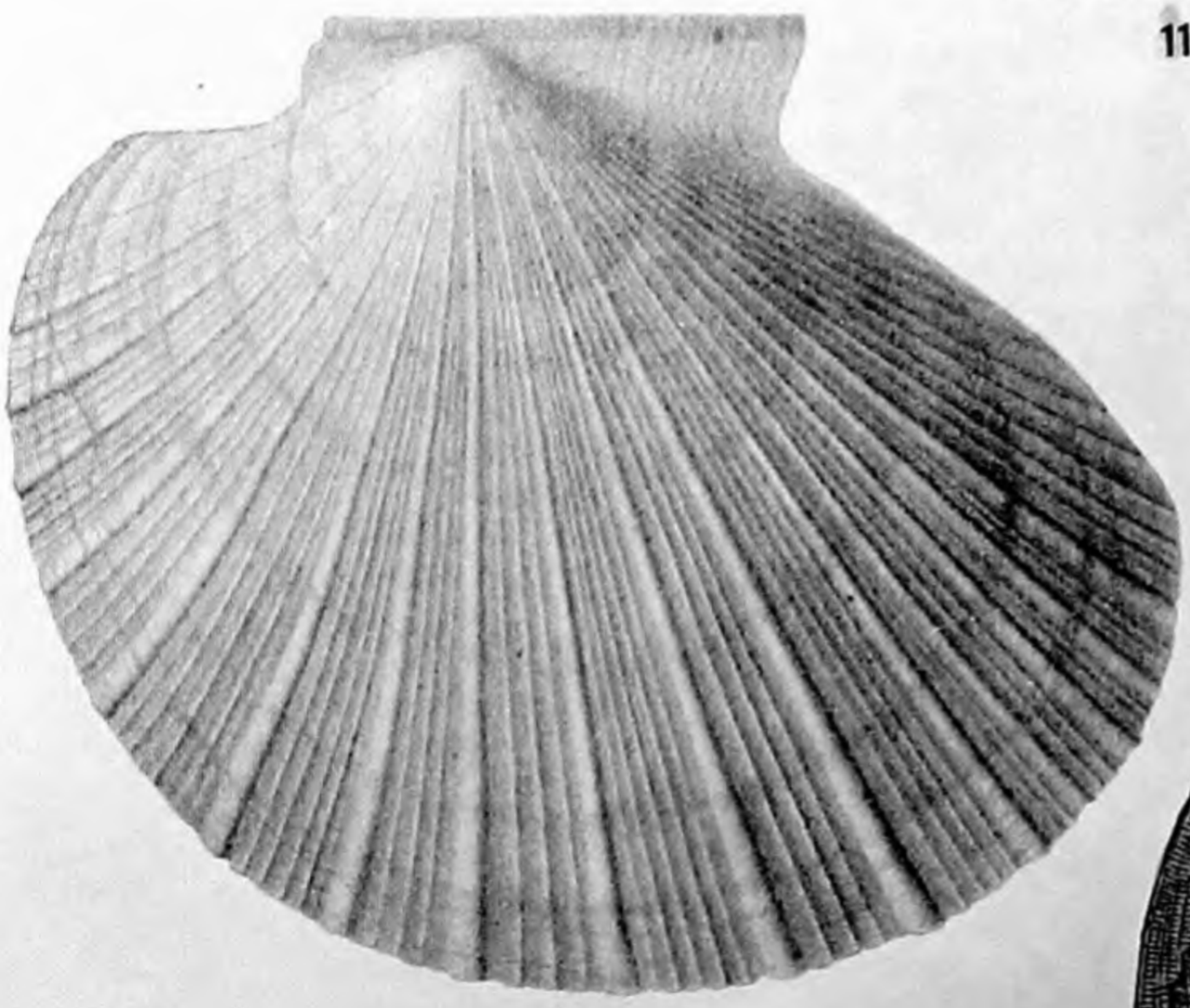

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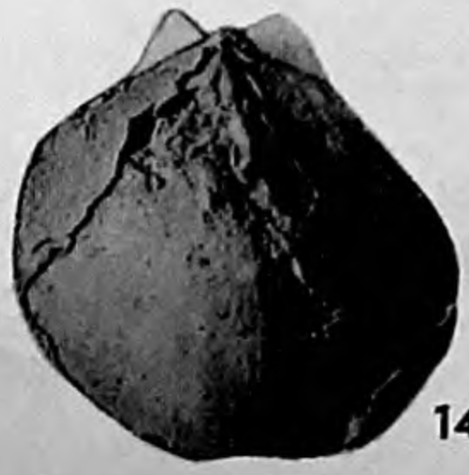

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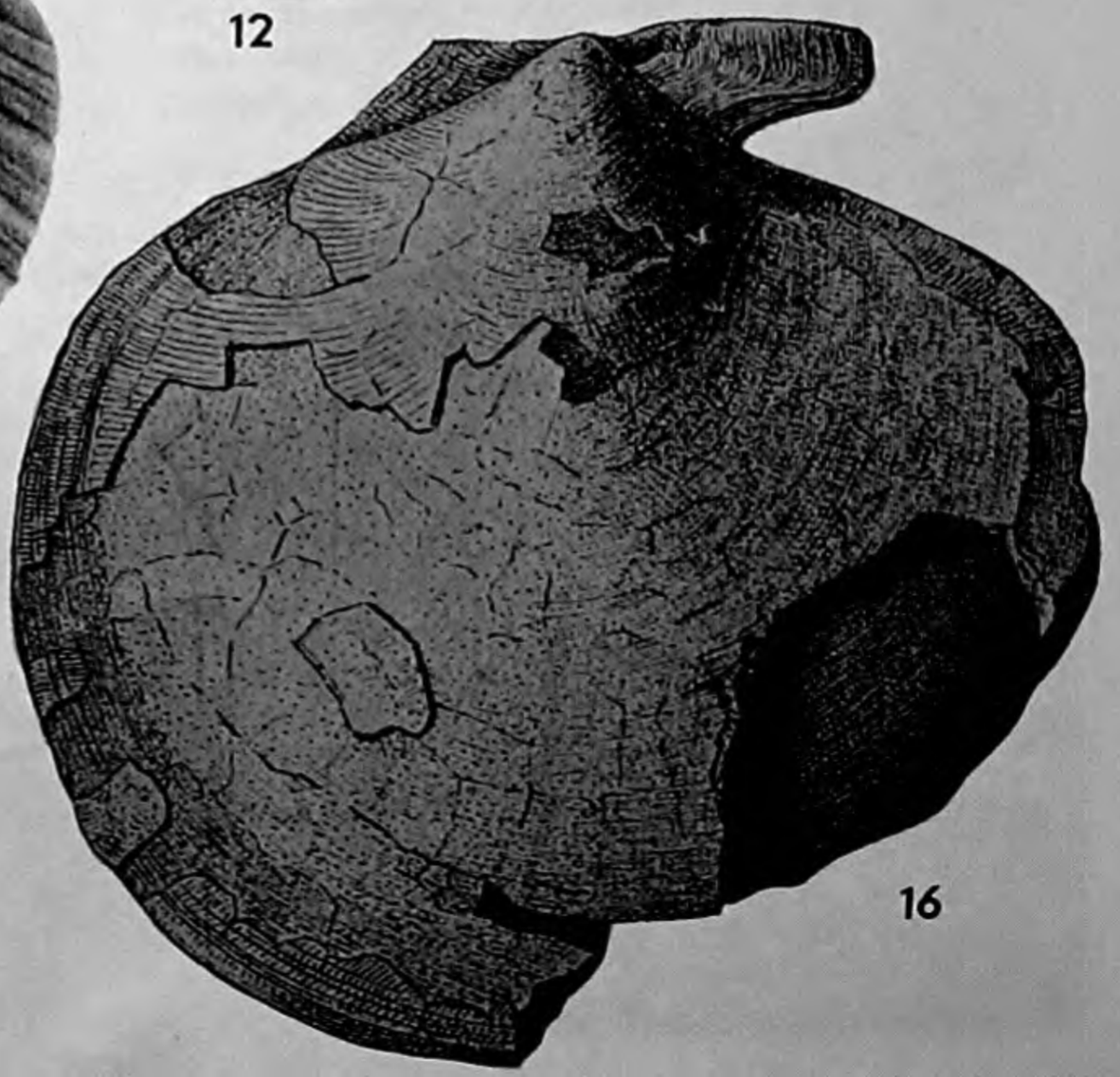

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ACANTHOPECTEN Girty 1903

(**Pecten carboniferus* Stevens). Distinguished from *Aviculopecten* by its large, angular plications, spinose margin and growth lines. **Miss.–Perm.**

***A. carboniferus** (Stevens) (**159**—26, 27). Right valve less spinose and less strongly plicate than left. **Penn.:** W. Va. to Colo. and N. Mex.

A. coloradoensis (Newberry) (**159**—25). **Perm.:** Leonard and Word of Tex.; Kaibab of Ariz. and Nev.

VERTUMNIA Hall 1884

(**Pterinea reversa*). General expression of the shell pterinopectinoid; exceptional in having left valve flat or concave; right valve convex. **Dev.**

V. simplex Pohl (**160**—1). **Dev.** (Milwaukee): Wis.

***V. reversa** (Hall) (**160**—2). **Dev.** (Chemung): N. Y., Pa.

PTERINOPECTEN Hall 1883

(**P. undosus*). Shell is more or less pectiniform; ligament area without resilifers, but with a series of asymmetrical chevron grooves below the beaks. **Dev.**

***P. undosus** Hall (**160**—6–8). **Dev.** (Hamilton): N. Y., Pa., Ind.

P. (***Pseudaviculopecten**) **princeps** (Conrad) (**160**—3). Rays nearly obsolete on the large ears, which are well differentiated from the shell body; type of subgenus. **Dev.** (Hamilton): Widespread in Appalachian and Mississippi Valley regions.

P. (**Dunbarella**) **rectilaterarius** (Cox) (**160**—4, 5). Shell high, subquadrate in outline (*Dunbarella* is very similar to *Pterinopecten* except for the bifurcate costae on right valve). **Penn.:** Southern Appalachians and Mississippi Valley region.

LYRIOPECTEN Hall 1877

(**Avicula orbiculata*). Shell differs from *Pterinopecten* in its small, somewhat rounded anterior ear. **Dev.**

***L. orbiculatus** (Hall) (**160**—9, 10). **Dev.** (Hamilton): N. Y., Pa.

L. tricostatus (Vanuxem) (**160**—13). Radial ornamentation of three sizes, crossed by fine concentric lines. **Dev.** (Chemung–Canadaway): N. Y., Md., W. Va.

CRENIPECTEN Hall 1883

(**Pecten? crenulatus*). Shell like *Aviculopecten* in form; hinge margin with a series of small, subequal cartilage pits throughout its entire length. **Dev., Miss.**

C. amplus Hall (**160**—12). **Dev.** (Canadaway): N. Y.

EUCHONDRIA Meek 1874

(**Pecten neglectus* Geinitz). Like *Aviculopecten*, but with an unsymmetrical resilifer beneath the beak and with numerous pits on the two sides of it unequal in number and shape (in *Crenipecten* Hall these are practically equal in size). **Miss., Penn.**

***E. neglecta** (Geinitz) (**160**—11, 15). Right valve with concentric striae only on body of shell, but ribs on ears; left valve with more or less distinct costae. **Penn.:** Ill., Ia., Mo., Neb., Kan.

PECTEN Osbeck 1765

(**P. adscensionis*). Shell usually somewhat inequivalve, but excepting the ears usually approximately equilateral, suborbicular; hinge line straight, ears well developed, ventral one of right valve more or less separated from the main body of shell by a byssal notch; sculpture normally of external radiating ribs or striae; resilium triangular, situated in pit in middle of inside of hinge; the single adductor muscle scar large, rounded, dorsal. **Miss.–Recent.**

PECTEN, *ss.* Valves moderately and nearly equally inflated; radiating ribs small and numerous; hinge line short; ears of ventral valve large and extended; byssal notch deep and broad; ears of dorsal valve small, oblique; **Trias.–Recent.**

CHLAMYS Bolten 1798 (**Pecten islandicus* Müller) has numerous small ribs which are spinose or covered with conspicuous growth lines; ventral ear about twice as long as dorsal; **Trias.–Recent.**

PALLIUM Schumacher 1817 (**P. striatum*) has shell triangular, with relatively great altitude and short hinge line; few strong radii with impressed lines; **Tert.–Recent.**

AEQUIPECTEN Fischer 1886 (**Ostrea operculons* Linnaeus) has ears that are usually equal; byssal notch of moderate depth; ctenolium usually present but small; apparently intergrades with *Chlamys*, but differs in having fewer and more distinct ribs, circular outline, and nearly equal ears; **Jura.–Recent.**

LYROPECTEN Conrad 1862 (**Pallium estrellanum* Conrad) has shell thick; valves about equally convex, strengthened with large radial ribs upon which and the interspaces are secondary striations; surface with concentric constrictions; ventral ear

PLATE 160

[Figures are x1 and after Newell [Kan G S 10] unless otherwise indicated.]

1, 2. Vertumnia spp. 1, V. simplex [Mil Pub Mus, B 11]. Left valve of holotype. **2. V. reversa** [Pal N Y 5]. A specimen with valves united. **3–8. Pterinopecten spp.** [3, 7 and 8 from Pal N Y 5]. **3. P. (Pseudaviculopecten) princeps.** Left valve. **4, 5. P. (Dunbarella) rectilaterarius.** Two valves joined, and a left valve. **6–8. P. undosus.** Hinge view of a left valve of a hypotype; right valve; left valve. **9, 10. Lyriopecten orbiculatus** [Pal N Y 5]. Ligamental area of right valve (x3); left valve showing portion of cardinal area. **11, 15. Euchondria neglecta.** Hinge greatly magnified, showing oblique cartilage and smaller lateral pits [Ill G S 5]; small left valve of hypotype (x5). **12. Crenipecten amplus** [Pal N Y 5]. Left valve showing cartilage pits along hinge line. **13. Lyriopecten tricostatus** [Pal N Y 5]. Large left valve with striated ligamental area. **14. Pecten (Pernopecten) prosseri.** Left valve of lectotype. **15. Euchondria neglecta** (see fig. 11, this plate). Small left valve of hypotype (x5). **16. Pecten (Camptonectes) bellistriatus** [USGS, M 32]. Right valve (x1.2).

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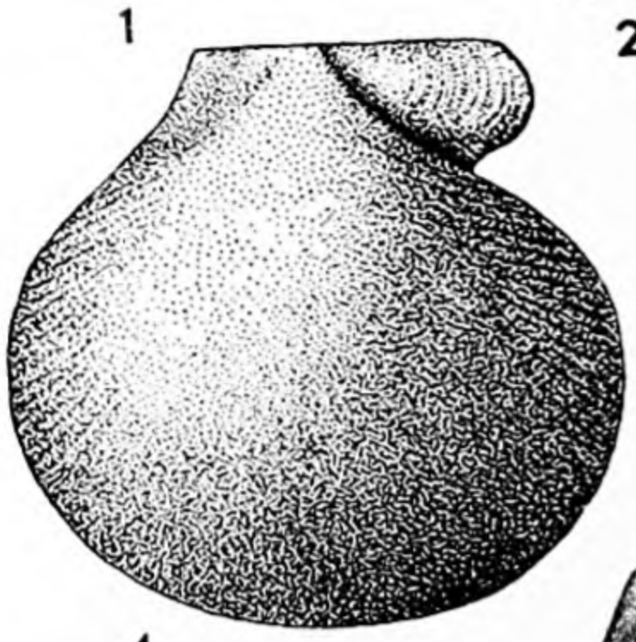

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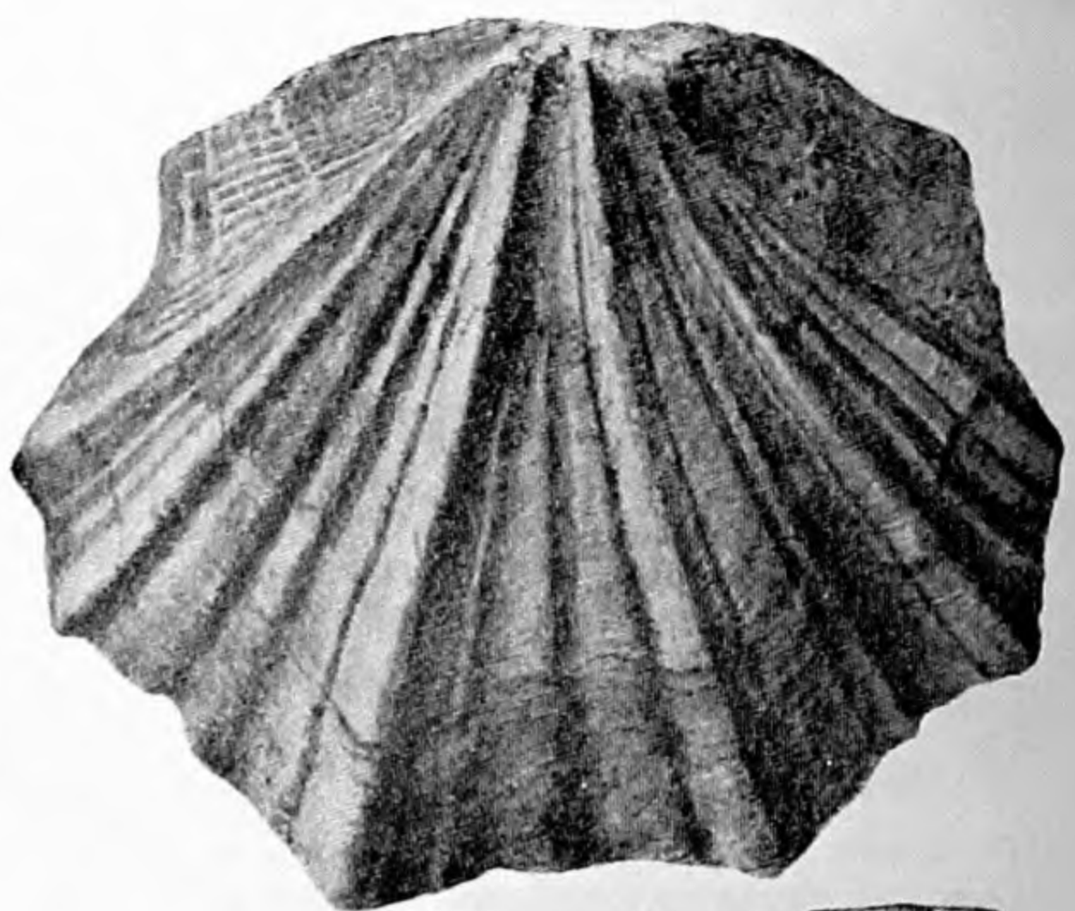

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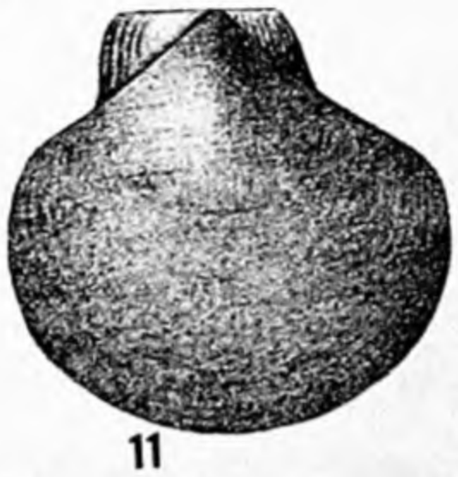

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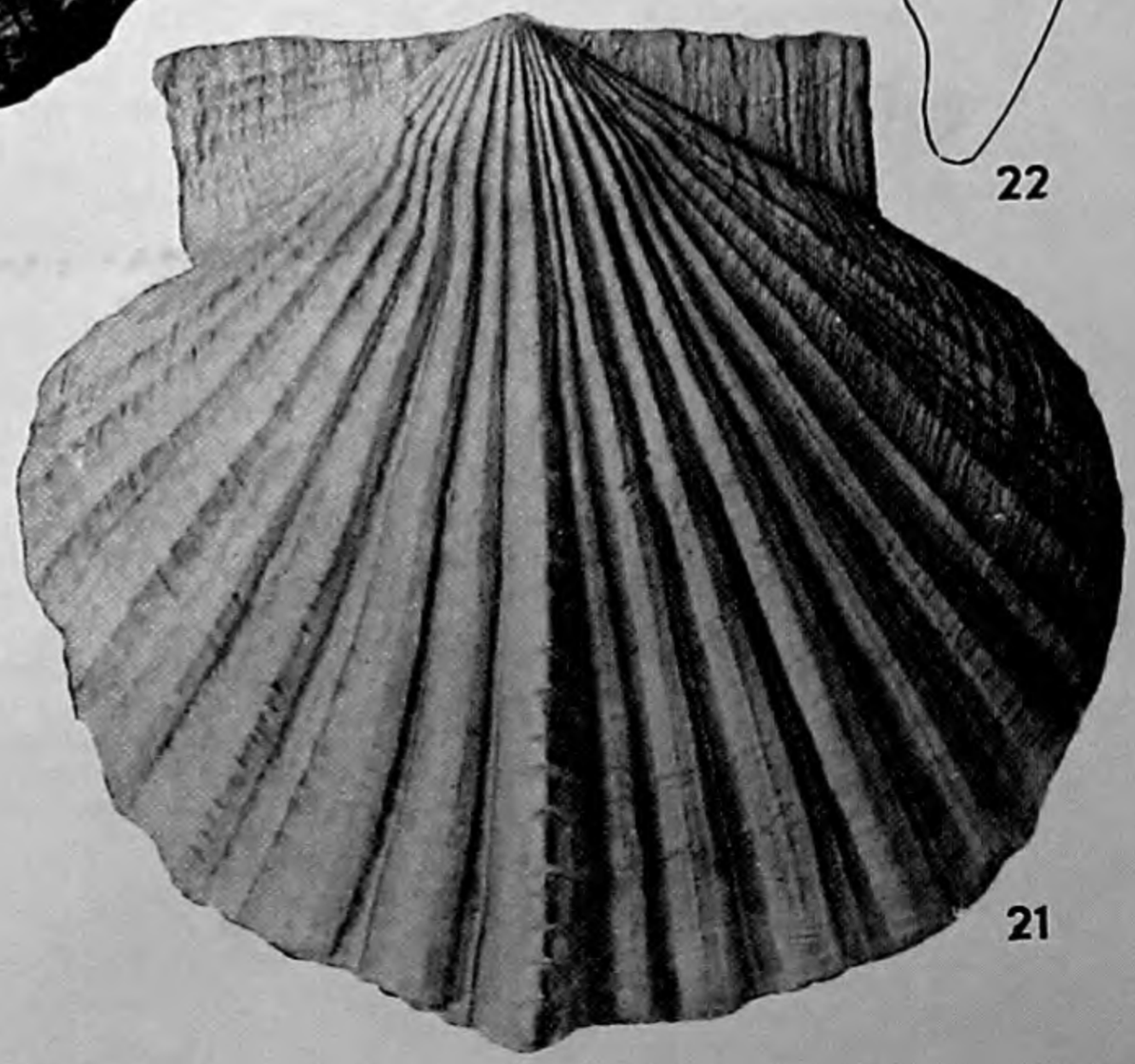

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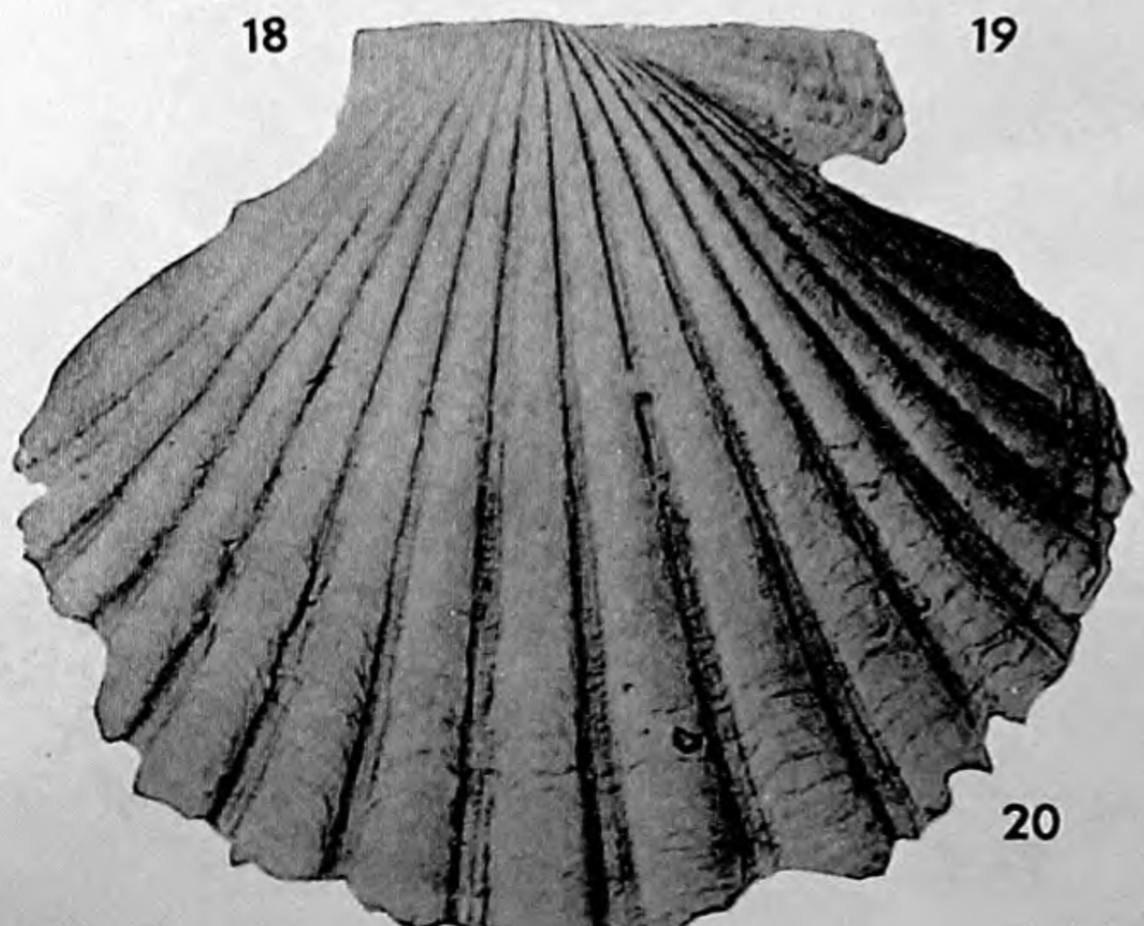

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somewhat longer than dorsal with a shallow byssal notch; **Olig.–Recent.**

PATINOPECTEN Dall 1898 (**Pecten caurinus* Gould) is a large, thin, flat, pectinoid shell with strong external ribs without minor striations (*Placopecten* has only external radial riblets); **Olig.–Recent.**

CAMPTONECTES Meek 1864 (**Pecten lens* Sowerby) has valves small, thin, slightly inflated, marked by fine, almost microscopic and more or less vermicular groovings which radiate from the umbo and are deflected laterally from a median line on each valve; **Jura.–Cret.**

PERNOPECTEN Winchell 1865 (**Aviculopecten limaformis* White and Whitfield) has smooth biconvex shell with small, triangular auricles, those of left valve extending high above cardinal axis, whereas the dorsal margin of right valve is straight; auricle set off sharply from shell body; two broad sulci extend from beaks toward ventral border of each valve just within the front and rear margins of shell, producing a flattened marginal area along front and rear parts of shell, the posterior one being somewhat longer and producing a slight posteroventral projection of the margin, making the shell inequilateral; **Miss.–Perm.**

ENTOLIUM Meek 1865 (**Pecten demissus* Phillips) differs from *Pernopecten* chiefly in its equilateral shell; **Trias.–Cret.**

SYNCYCLONEMA Meek 1864 (**Pecten hallii* Gabb) is a small, vertically ovate pectinoid shell with very short hinge line; ears very small, the anterior larger; no defined byssal sinus; surface only concentrically striated; **U. Cret.**

JANIRA Schumacher 1817 (**J. niternudia*) right valve much inflated, left flat; **Tert.–Recent.**

NEITHEA Drouet 1825 superficially resembles *Janira;* at present it is used as a distinct genus by most authors for the **Cretaceous** species of this type of shell.

AMUSIUM Bolten 1798 (**Ostrea pleuronectes* Linnaeus) is a large, thin, almost flat pectinoid shell with raised radial ribs internally; smooth externally or faintly striated; ears small, short, subequal: byssal notch inconspicuous or absent; **U. Cret.–Recent.**

PSEUDAMUSIUM Klein 1853 (**Ostrea hybrida* Gmelin) differs from *Amusium* in absence of internal riblets and a deeper byssal notch; **Cret.–Recent.**

PLAGIOCTENIUM Dall 1898 (**Pecten circularis* Sowerby). Like *Aequipecten* but without radial striation; ribs strong, frequently smooth above; ears about equal but differing in shape; **Tert.–Recent.**

P. (Pernopecten) prosseri Mark (= **P. aviculatus** Swallow) (**160**—14). Surface with fine, close concentric striae and occasional traces of radiating ones. **Miss.:** Ohio, Ariz.; **Penn.:** Ohio to Wyo. and Okla.

P. (Entolium) semiplicatus (Hyatt) (**161**—3). **L. Jura.:** Cal.

P. (Camptonectes) bellistriatus Meek (**160**—16). **U. Jura.:** S. Dak., Wyo., Idaho, Utah.

P. (Camptonectes) pertenuistriatus Hall and Whitfield. Beak attenuated (umbonal angle about 90°); valves flattened; average height 25 mm, width 18 mm. **U. Jura.:** Mont., Wyo., Idaho, Utah.

P. (Entolium) operculiformis Gabb (**161**—1). Surface smooth, polished. **Cret.:** Ore. (Horsetown), Cal. (Horsetown, Chico).

P. (Chlamys) complexicosta Gabb (**161**—5). Surface marked with minute radiating striae and with 12 to 14 obscure radiating ribs with smaller ribs intercalated in some specimens. **L. Cret.:** Cal (Paskenta).

P. (Neithea) texanus Roemer (**161**—2). Surface of convex valve marked by six rounded ribs between which lie two lower though equal rounded ribs. **L. Cret.** (Washita and Fredericksburg): Tex.

P. (Neithea) roemeri Hill (**161**—6). **L. Cret.:** Tex. (Buda); Mex.

P. (Camptonectes) platesea White (**161**—4). Surface with fine radiating striae which recurve at sides of shell. **U. Cret.** (Coloradoan): Utah, N. Mex., Ariz.

P. venustus Morton (**161**—13). Both valves convex; about 15 of the radial costae are medially sulcate. **U. Cret.** (*Exogyra costata* zone): Atlantic and Gulf Coast regions.

P. conradi (Whitfield) (**161**—9, 10). Surface of right valve crossed by crowded concentric folds which do not extend across the ears, and usually marked also with five to six radiating lines; left valve usually smooth. **U. Cret.:** N. J. (Matawan–Monmouth).

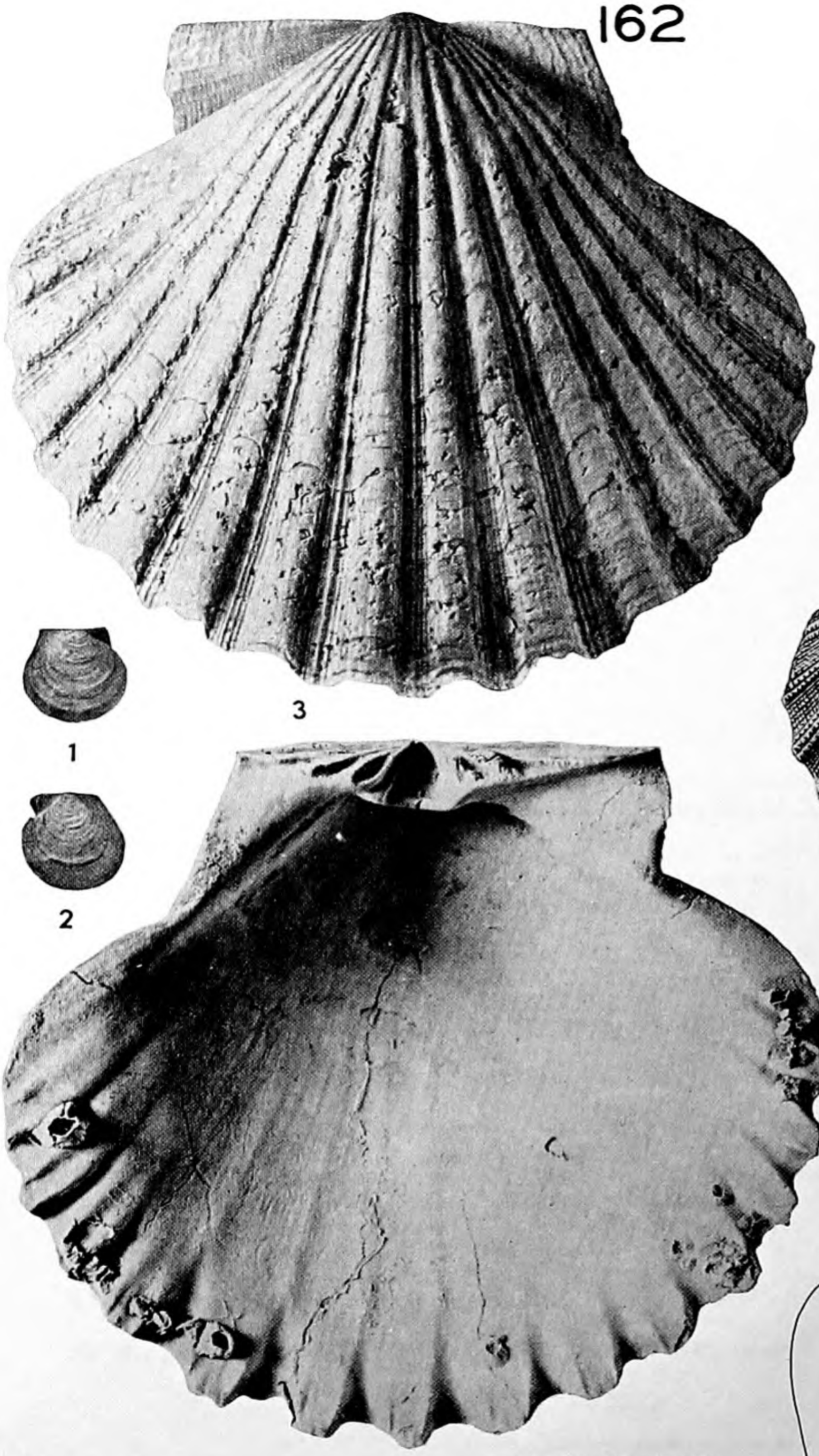
P. simplicius Conrad (**161**—11, 12). Differs from *P. conradi* in having surface of valves smooth. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain to Tex.

P. (Chlamys) nebrascensis Meek and Hayden (**161**—7, 8). Small, suborbicular; both ears separated from body of shell by rather angular depressions.

PLATE 161

[Figures are x1 unless otherwise indicated.]

1–27. Pecten spp. 1. P. (Entolium) operculiformis [Pal Cal 1]. Type. **2. P. (Neithea) texanus** [USGS, B 205]. **3. P. (Entolium) semiplicatus** [USGS, PP 175]. Left valve. **4. P. (Camptonectes) platesea** [USGS, B 106]. Right valve of type. **5. P. (Chlamys) complexicosta** [USGS B 133]. Medium-sized right valve. **6. P. (Neithea) roemeri** (x0.4) [USGS, B 205]. **7, 8. P. (Chlamys) nebrascensis** [USGS Ter 9]. Side view and exterior of a valve with one auricle broken away. **9, 10. P. conradi** [Pal N J 1]. Enlarged surface; left valve (x3). **11, 12. P. simplicius** [Pal N J 1]. Exteriors of both valves (x3). **13. P. venustus** [Md G S, U Cret]. Right valve (x3). **14. P. (Chlamys) johnsoni** [Md G S, Eoc]. Left exterior of type. **15, 16. P. (Syncyclonema) halli** [USGS Ter 9]. A left valve and a somewhat larger right valve. **17, 18. P. (Chlamys) choctavensis** [Md G S, Eoc]. Left (x1.6) and right (x3) exteriors. **19. P. (Pallium) swifti nutteri** [USGS, B 398]. Right valve. **20. P. (Lyropecten) estrellanus terminus** [USGS, PP 47]. Right exterior of type. **21, 22. P. (Chlamys) fucanus** [USGS, PP 47]. Left valve and profile view.



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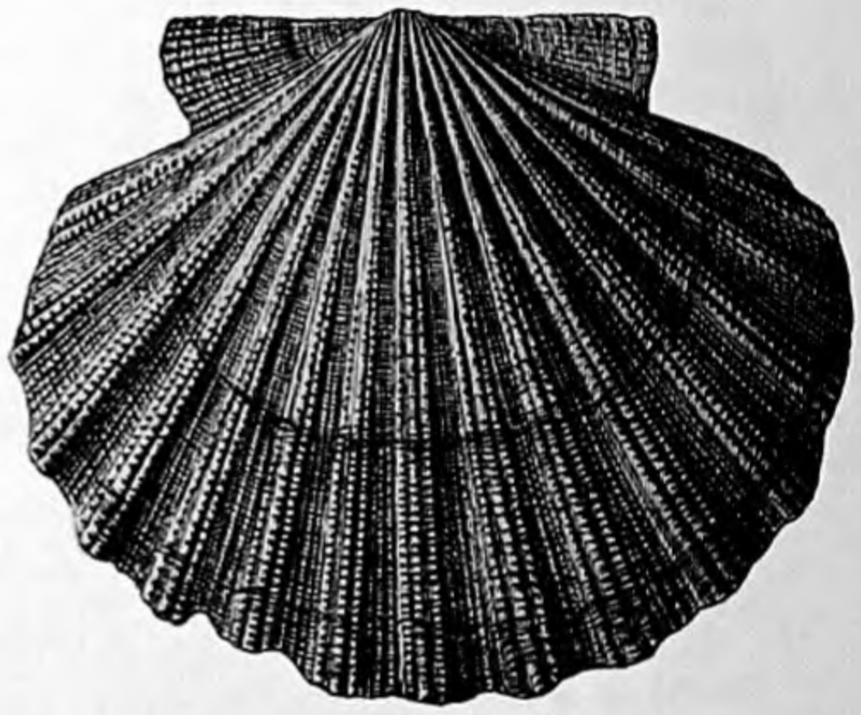

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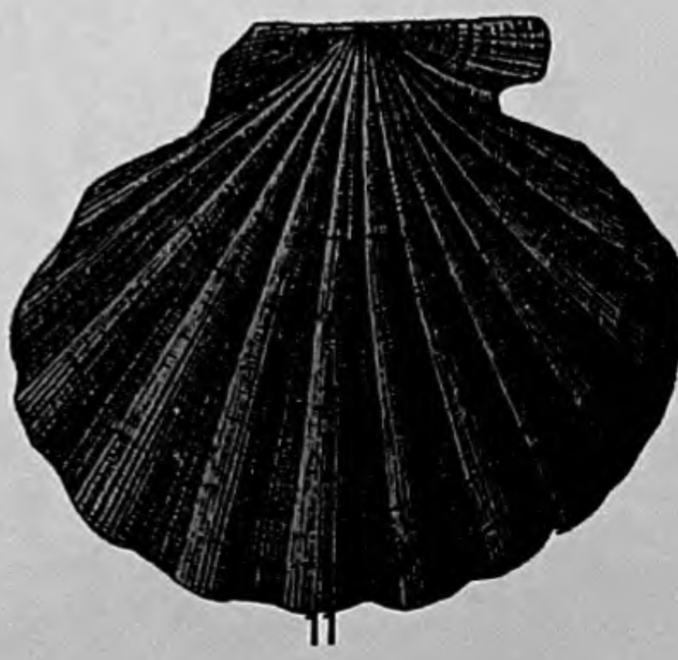

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U. Cret. (Montanan): Sask., Alta.; N. Dak., Mont., Wyo., N. Mex.

P. (*Syncyclonema) halli Gabb (= **P. rigidus** Hall and Meek) (**161**—15, 16). **U. Cret.** (Montanan): Sask. and Alta. to N. Mex.

P. (Chlamys) choctavensis Aldrich (**161**—17, 18). Surface imbricated when mature. **Eoc.:** Aquia and Nanjemoy of Md. and Va.; Wilcox and Claiborne of Ala.

P. (Chlamys) greggi Harris. Differs from preceding in its small number of ribs and their lack of bifurcation and imbrication. **Eoc.** (Wilcox): Ga., Ala.

P. (Chlamys) johnsoni Clark (**161**—14). Small; a few ribs implanted at front of shell. **Eoc.:** Md., Miss.

P. (Chlamys) wahtubbeanus Dall. Differs from preceding in having fewer ribs (about 14), each with two or three imbricated radial striae increasing by bifurcation. **Eoc.** (Claiborne and Jackson): Ala., Miss., La.

P. (Aequipecten) perplanus Morton. Ribs subangular, about 23, with sloping sides and equally wide interspaces; an obsolescent thread on each side of the median keel of each rib; all crossed by regularly spaced, low lamellae, slightly produced over each rib; byssal notch conspicuous but not deep; height 34 mm, width 35 mm (about twice the length of the hinge). **Eoc.** (Jackson): Gulf Coastal Plain.

P. (Lyropecten) madisonius Say (**162**—6). Byssal notch one-third length of ear. **Mioc.:** N. J. (Kirkwood), Md. and Va. (Calvert and Choptank).

P. (Lyropecten) jeffersonius Say (**162**—11). Differs from preceding in its fewer ribs, with about six striae on top of each; byssal notch barely one-eighth the length of ear; this species grades into preceding. **Mioc.:** Yorktown of Va. to Fla.; Vaqueros of Cal.

P. (Chlamys) fucanus Dall (**161**—21, 22). Surface reticulate; right valve with more or less unequal, squarish, radially striate ribs, with at times smaller riblets between; left valve with radially striate ribs, the median one stronger than the rest and usually with imbricating scales. **Mioc.:** Alaska; Wash.

P. (Lyropecten) jeffersonius septenarius Say (**162**—7). **L. Mioc.:** Md., Cal. (Vaqueros).

P. (Plagioctenium) andersoni Arnold (**162**—8–10). **L. Mioc.:** Cal. (Vaqueros).

P. (Placopecten) marylandicus Wagner (**162**—5). **M. Mioc.:** Md. (Choptank), Va.

P. (*Lyropecten) estrellanus (Conrad) (**162**—3, 4). Shell quite convex; right valve with somewhat square ribs, separated by interspaces narrower than ribs and in each of which is a square riblet; both valves marked by radiating lines especially on anterior and posterior portions. **Mioc., Plioc.:** Cal. (Vaqueros Jacalitos).

P. (Lyropecten) estrellanus terminus Arnold (**161**—20). **U. Mioc., L. Plioc.:** Cal.

P. (Amusium) mortoni Ravenel (**163**—1). Thin; inside of valves marked by 18 to 24 radiating double ribs. **U. Mioc.:** Va. to Fla.; **Plioc.:** S. C. to Fla.

P. (Pseudamusium) pedroanus (Trask) (= **P. peckhanis** Gabb) (**162**—1, 2). Shell transparent; the delicate radial striations often worn away. **Mioc.:** Wash. to Cal.; **Plioc.:** Cal.; **Recent:** Bering Sea to Mex.

P. (Pallium) swifti nutteri Arnold (**161**—19). Characterized by bifurcation of main plications of right valve, and corresponding development of strong intercalaries on the left. **Plioc.:** Cal.; Japan.

P. (Patinopecten) healeyi Arnold (**163**—2). Left valve marked by rounded ribs and each of the wide interspaces marked by a smaller rib; right with squarish ribs, more or less bifurcating; interspaces narrow. **Plioc.:** Cal.; Mex.

P. (Plagioctenium) circularis Sowerby (**157**—5, 6). **Pleist., Recent.:** Gulf of Cal. to Panama and Colombia, S. America.

PLICATULA Lamarck 1801

(**Spondylus plicatus* Linnaeus). Inequivalve, nearly equilateral, compressed; surface bearing coarse, radial, and often divaricate ribbing; teeth long, shallow and crenulate, often diverging at a sharp angle; muscle scar single, eccentric; shell sessile. **Trias.–Recent.**

P. hydrotheca White (**163**—7). **U. Cret.** (Coloradoan): Utah.

P. densata Conrad (**163**—8, 9). Thick; irregularly plicated. **U. Mioc.:** N. J. to Fla.

DIPLOSCHIZA Conrad 1866

(**D. cretacea*). Shell broadly attached by convex right valve; left valve concave; umbos of both valves thin, easily broken away; teeth absent; inner surface of both valves lined to near margin with fine, sharp, irregularly spaced radiating ridges. **U. Cret.**

***D. cretacea** Conrad (**163**—3–6). **U. Cret.** (a narrow zone above the middle of *Exogyra ponderosa* zone): Ala., Miss., Tex.

LIMA Bruguière 1797

(**Ostrea lima* Linnaeus). Shell inflated, marked by radial sculpture; valves equal, gaping anteriorly and sometimes posteriorly; umbos prominent, beaks

PLATE 162

[Figures are x1 and after Glenn [Md G S, Mioc] unless otherwise indicated.]

1–11. Pecten spp. 1, 2. P. (Pseudamusium) pedroanus [USGS, B 398]. Right and left exteriors. **3, 4. P. (Lyropecten) estrellanus** [USGS, PP 47]. Exterior and interior of a left valve. **5. P. (Placopecten) marylandicus.** Left valve. **6. P. (Lyropecten) madisonius.** Left valve (x0.5). **7. P. (Lyropecten) jeffersonius septenarius.** Right exterior (x0.5). **8-10. P. andersoni.** 8: Right exterior [USGS, B 398]; 9, 10: Type specimen showing impression of left interior to which is clinging some of left valve, and profile view of same [USGS, PP 47]. **11. P. (Lyropecten) jeffersonius.** Right valve (x0.5).

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pointed; hinge line straight, terminating in slightly unequal ears; hinge area of each valve triangular and with central resilifer; teeth absent; muscle impression single and large. **Penn.–Recent.** Abundant in the **Mesozoic.**

L. retifera Shumard (**163**—10). **Penn.:** Ohio to Okla.

L. occidentalis Hall and Whitfield (**163**—14). Anterior border of shell strongly concave. **U. Jura.:** Idaho (Twin Creek), Utah.

L. wacoensis Roemer (**163**—11). **L. Cret.** (Fredericksburg, Washita): Tex.; Mex.

L. utahensis Stanton (**163**—12). **U. Cret.** (Coloradoan): Utah, N. Mex.; Mex.

L. reticulata Forbes (**163**—13). Shell small (10 to 15 mm long). **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

Superfamily ANOMIACEA

ANOMIA Linnaeus 1758

(**A. ephippium*). Thin, translucent, irregular or subcircular, attached by a calcified byssus passing through a rounded sinus near umbo of right valve, which is flattened, conforming to subjacent surface and bearing a central adductor impression; left valve larger, convex, with four muscle scars on a central area — three byssal and one adductor; teeth absent; ligament more or less internal and supplemented by a resilium. **Jura.–Recent.**

A. argentaria Morton (**163**—18, 19). **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain to Tex. and Mex.

A. gryphorhynchus Meek (**163**—24). Brackish water dwellers. **U. Cret.** (Montanan, Lance): Widely distributed in Rocky Mountain region, Sask. to N. Mex.

A. micronema Meek (**163**—17). Umbos overarching cardinal margin; surface bearing fine bifurcating radial costae which are irregular in their course, being interrupted by concentric striae; brackish water dwellers. **U. Cret.** (Montanan, Lance): Widely distributed in the Rocky Mountain region, Sask. and Alta. to Colo.; possibly to Mex.

A. tellinoides Morton (**163**—15, 16). **U. Cret.:** In lower part of zone containing *Exogyra costata* of Atlantic and Gulf Coastal Plain, i.e., L. Monmouth, L. Navarro, L. Ripley, and equivalents.

PARANOMIA Conrad 1860

(**Placuna scabra* Morton). Irregular, inequivalve; upper valve depressed-convex, lower flattened, often attached near umbo to extraneous objects; very thin, probably perforate; entire shell surface bearing distant, rounded, radiating ribs. **U. Cret.**

***P. scabra** (Morton) (**163**—20, 21). Ribs produced at irregular intervals into hollow spines. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain to Tex.

Section E. DYSODONTA

Superfamily MYTILACEA

MODIOLOPSIS Hall 1847

(**Cypricardites ovatus* Conrad). Shell thin, obliquely elongate, very inequilateral, with small anterior and large posterior end; beaks nearly at anterior ends; valves crossed by an oblique depression extending backward from anterior portion of umbo and forming a ventral sinus; hinge plate thin, with a single undefined subrostral tooth and socket in each valve; muscle impressions two, the anterior deep, posterior large and faint; ligament external, deep-seated; differs from *Modiomorpha* in lacking well defined teeth. **Ord., Sil.**

M. mytiloides Hall (**163**—27). Surface marked with fine concentric lines interspersed with stronger wrinkles. **Ord.** (Trenton): N. Y., Wis., Minn.

M. valida Ulrich (**163**—28). **U. Ord.** (Richmond): Ohio.

M. concentrica Hall and Whitfield (**163**—29, 30). **Ord.** (Richmond): Ohio, Ind., Ky.

MODIOMORPHA Hall 1869

(**Pterinea concentrica* Conrad). Subovate, widest posteriorly, crossed obliquely from beak to base by a depression constricting the basal margin; beaks small, compressed; surface bearing rugose or undulating concentric striae; hinge with strong wedge-shaped tooth in left valve and corresponding cavity in right; no lateral teeth present; ligament external, attached to thickened shell margin, which is often longitudinally grooved for its reception; pallial line simple. **Dev.**

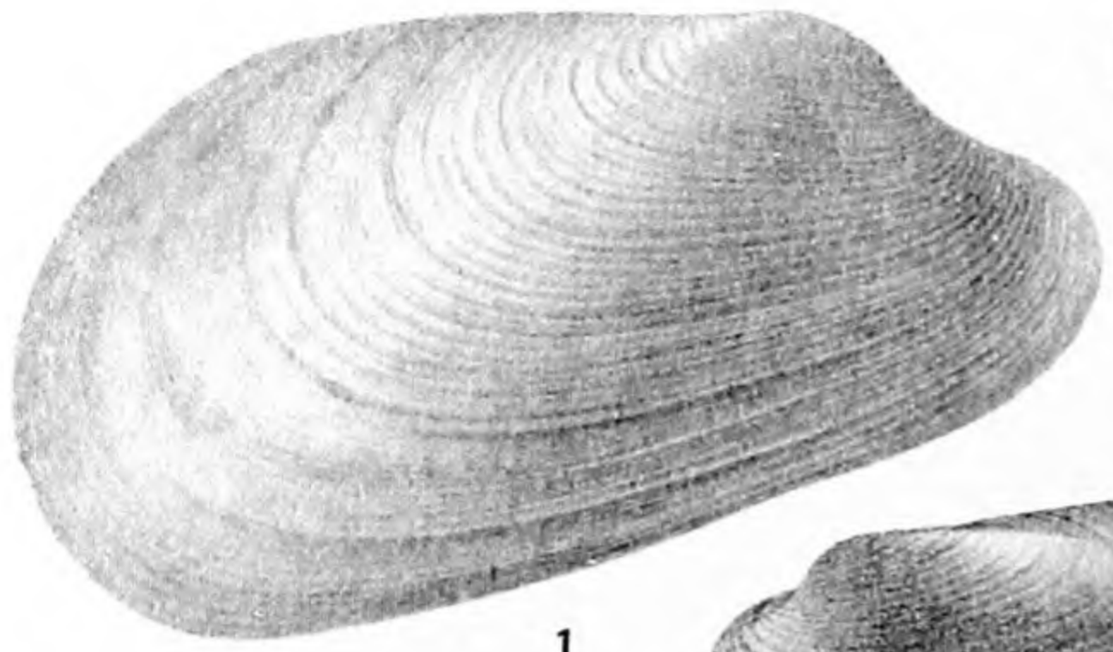
M. mytiloides (Conrad) (**164**—1). **Dev.** (characteristic of Hamilton, persisting as "recurrent" zones into basal Chemung): Ont.; N. Y. to Md., Ind., Ky., Wis.

***M. concentrica** (Conrad) (**164**—2). **Dev.** (Hamilton–Naples): N. Y. to Md. to Ind., Wis.

PLATE 163

[Figures are x1 unless otherwise indicated.]

1. Pecten (Amusium) mortoni [Md G S, Mioc]. Right valve (x0.5). **2. Pecten (Patinopecten) healeyi** [USGS, PP 47]. Right valve (x0.5). **3–6. Diploschiza cretacea** (x2) [JP 8]. Left exterior and interior; right interior and exterior. **7–9. Plicatula** spp. **7. P. hydrotheca** [USGS, B 106]. Upper valve. **8, 9. P. densata** [USGS, PP 142]. Exterior and interior of right valve. **10–14. Lima** spp. **10. L. retifera** [Kan G S 6]. Left valve. **11. L. wacoensis** [U Tex B 2838]. Left valve. **12. L. utahensis** [USGS, B 106]. Left valve. **13. L. reticulata** [Md G S, U Cret]. Right exterior (x5). **14. L. occidentalis** [USGS, PP 152]. Left valve. **15–19. Anomia** spp. **15, 16. A. tellinoides** [Md G S, U Cret]. Right exterior and interior. **17. A. micronema** [USGGS Ter 1878 (Hayden)]. Exterior of upper valve. **18, 19. A. argentaria** [USGS, PP 137]. Right exterior and interior. **20, 21. Paranomia scabra** [Pal N J 4]. Lower and upper valves. **22, 23. Modiolodon oviformis** [Ohio G S 7]. Portion of hinge and impression of left interior. **24. Anomia gryphorhynchus** [USGS, PP 98]. **25, 26. Modiolodon patulus** [Minn G S 3 (2)]. Impression of left interior, and a small specimen. **27–30. Modiolopsis** spp. [Minn G S 3 (2)]. **27. M. mytiloides.** Impression of left interior. **28. M. valida.** Hinge of right valve. **29, 30. M. concentrica.** Exterior and impression of interior of left valve.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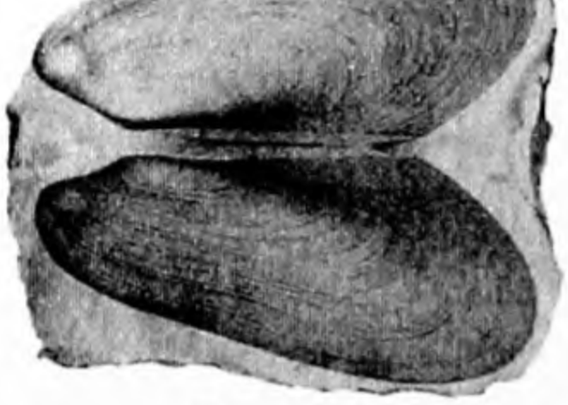
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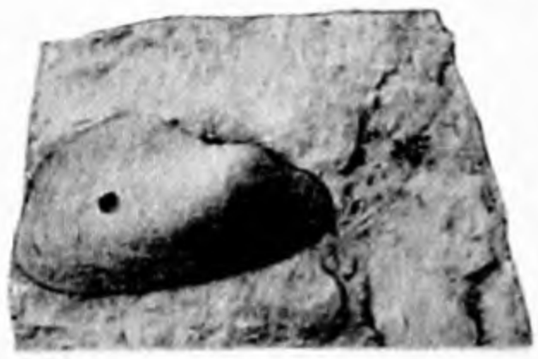
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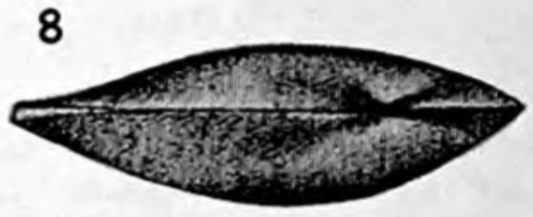
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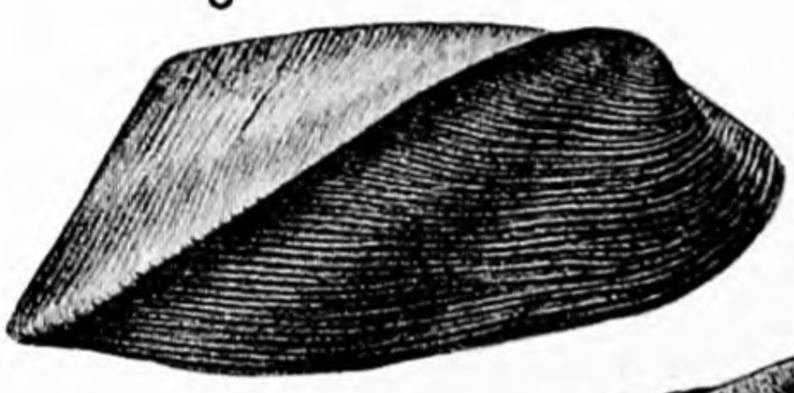
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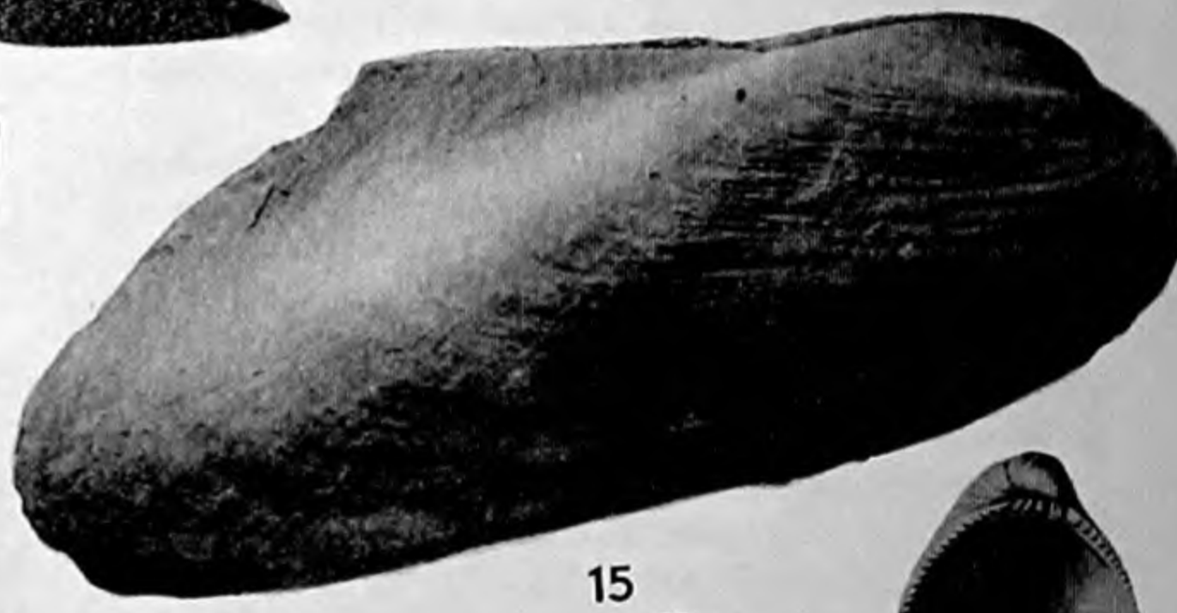
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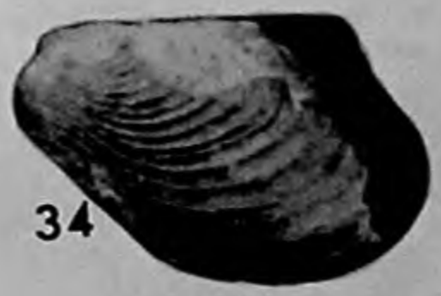
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MODIOLODON Ulrich 1893

(**Modiolopsis oviformis*). Shell ovate, differing from *Modiolopsis* and *Modiomorpha* in possessing one to three oblique cardinal teeth in each valve; hinge much like that of *Ischyrodonta*. **Ord.**

***M. oviformis** (Ulrich) (**163**—22, 23). Surface bearing faint concentric striae; differs from *Modiodesma modiolare* in its cardinal teeth and more oval shape. **Ord.** (Trenton): Ky., Tenn.

M. patulus Ulrich (**163**—25, 26). Wider, more erect, and more uniformly convex than *M. oviformis*. **Ord.** (Trenton): Que.; Ky., Minn., Ia.

COLPOMYA Ulrich 1893

(**C. constricta*). Inequilateral; hinge and basal margin subparallel; strong umbonal ridge; broad mesial furrow distinct; beneath right beak is a toothlike prominence which fits into a corresponding depression in opposite valve, differing thus from *Modiolodon*; beneath this depression in left valve is a strong projecting process. **Ord., Sil.**

***C. constricta** Ulrich (**164**—4, 5). **Ord.** (Trenton): Ky., Tenn.

WHITEAVESIA Ulrich 1893

(**Modiolopsis cincinnatiensis* Hall and Whitfield). Very similar to *Modiolopsis*, but differs in its thinner hinge plate and shell, in convex basal outline, and absence of mesial furrow; differs from *Modiodesma* in its more prominent umbonal region. **Ord.**

***W. cincinnatiensis** (H and W) (**164**—3). **Ord.** (U. Trenton): Cincinnati region.

MODIODESMA Ulrich 1924

(**Pterinea modiolaris* Conrad). Differs from *Whiteavesia* in having much less prominent and shorter umbos, longer ligament and thicker shell; it differs from *Modiolopsis* in having beaks farther from anterior end and in lacking mesial depression, ventral sinus, and deeply impressed anterior muscle scar. **Ord.**

***M. modiolare** (Conrad) (**164**—6). **Ord.** (Cincinnatian): N. Y. (Pulaski), Pa., Va., Cincinnati region.

EURYMYELLA Williams 1912

(**E. shaleri*). Shell subtriangular in outline, subalate posteriorly, narrowed anteriorly; umbonal ridge rounded and moderately elevated, with no sulcus anterior to it; hinge plate very narrow at the sides and without lateral teeth, fairly strong under the beaks where there is a cardinal tooth in each valve; pallial line simple. **Dev.**

***E. shaleri** Williams (**164**—7). **L. Dev.** (Moose River): Me.

EURYMYA Ulrich 1894

(**Modiolopsis plana* Hall). Somewhat triangular, with broad and winglike posterior and greatly narrowed anterior end; base oblique; hinge line straight; beaks small, near anterior extremity; hinge with obscure cardinal teeth in left valve and corresponding depresson in right, and with broad and longitudinally striated ligament area posterior to beaks; muscle impressions as in *Modiolopsis*; differs from that genus and *Modiomorpha* in the winglike posterior extremity and in presence of striated ligament area; it also lacks the mesial depression of *Modiolopsis*. **Ord.**

***E. plana** (Hall) (**164**—8, 9). Small, triangular, with strong concentric growth lines. **Ord.** (Black River): Wis., Minn.

ARISTERELLA Ulrich 1894

(**A. nitidula*). Subovate, small, moderately convex, nearly smooth, inequivalve; left valve the smaller; no mesial furrow; hinge apparently very thin and without teeth; muscle and pallial impressions as in *Whiteavesia*; differs from *Eurymya* and *Whiteavesia* in its unequal valves. **Ord.**

***A. nitidula** Ulrich (**164**—10, 11). Minute, nearly smooth. **Ord.** (Black River): Minn., Mo.

GONIOPHORA Phillips 1848

(**G. cymbiformis* Sowerby). Equivalve, very inequilateral, obliquely truncate posteriorly, rounded anteriorly; cardinal line straight; beaks small and closely incurved; umbo prominent; a strong angular ridge extends from umbo to posterior margin and a broad, undefined sinus from umbo to base; surface concentrically striated; like *Modiomorpha* in internal characters, but differing externally in form and in the strong angular umbonal ridge. (The subgenus COSMOGONIOPHORA McLearn 1918 (**Gonio-*

PLATE 164

[Figures are x1 unless otherwise indicated.]

1, 2. Modiomorpha spp. [Pal N Y 5]. **1. M. mytiloides.** Right valve. **2. M. concentrica.** Right valve. **3. Whiteavesia cincinnatiensis** [Pal Ohio 2]. Left valve of type. **4, 5. Colpomya constricta** [Minn G S 3 (2)]. Right exterior and left interior. **6. Modiodesma modiolare** [Pal N Y 1]. Both valves of holotype (x0.5). **7. Eurymyella shaleri** [USNM, Pr 42]. Right valve of holotype. **8, 9. Eurymya plana** [Minn G S 3 (2)]. Hinge enlarged (x2); left interior. **10, 11. Aristerella nitidula** [Minn G S 3 (2)]. Dorsal view enlarged; outline of right valve. **12–14. Goniophora** spp. **12. G. (Cosmogoniophora) bellula** [CGS, Mem 137]. Right valve of holotype. **13. G. hamiltonensis** [Pal N Y 5]. Right valve. **14. G. perangulata** [Pal N Y 5]. Left valve. **15–18. Volsella** spp. **15. V. recta** [USGS, B 398]. Right valve with outer surface remove l. **16. V. (Brachydontes) multilinigera** [USGS, B 106]. Left valve. **17. V. alabamensis** [Md G S, Eoc]. Right valve (x1.3). **18. V. saffordi** [B Am Pal 4]. Left valve. **19. Mytilus conradinus** [Md G S, Mioc]. Right valve (x0.25). **20–24. Crenella** spp. **20, 21. C. elegantula** [USGS Ter 9]. Right valve of type, anterior view; right exterior (x2). **22–24. C. serica** (x6) [Md G S, U Cret]. Exterior and interior views of left valve; dorsal view of combined valves. **25–27. Lithophaga carolinensis** (x2) [NCGS 5]. Left exterior, right interior, and anterior view of combined valves (scale to right is x1). **28–30. Dreissena tippana** [Md G S, U Cret]. Anterior view of combined valves; right exterior; left interior. **31–33. Pleuromya** spp. **31, 32. P. subcompressa** [U Kan Quart 9]. Right valve and cardinal view. **33. P. inconstans** [USGS, B 266]. Right valve. **34, 35. Newsomella ulrichi** [DUB, JSL 14]. Left and right valves.

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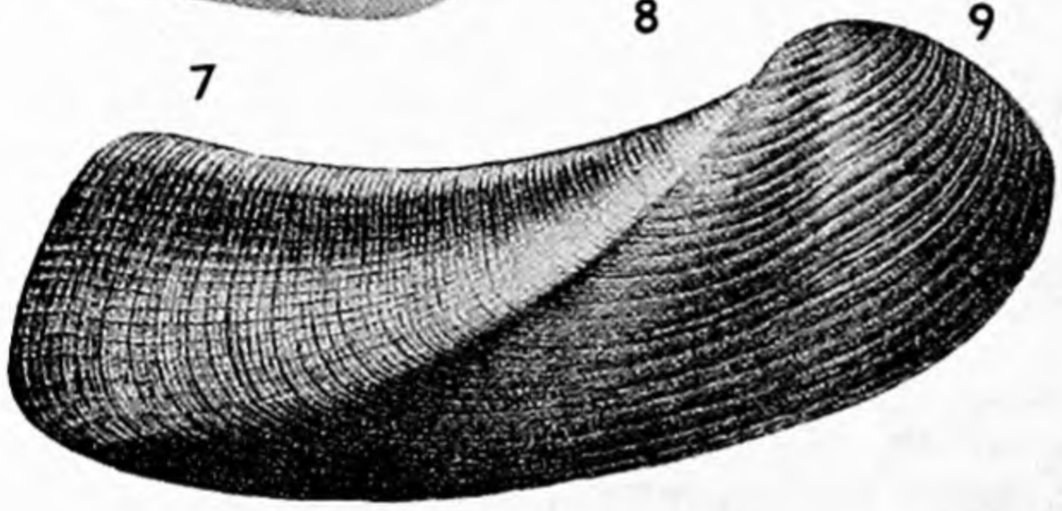

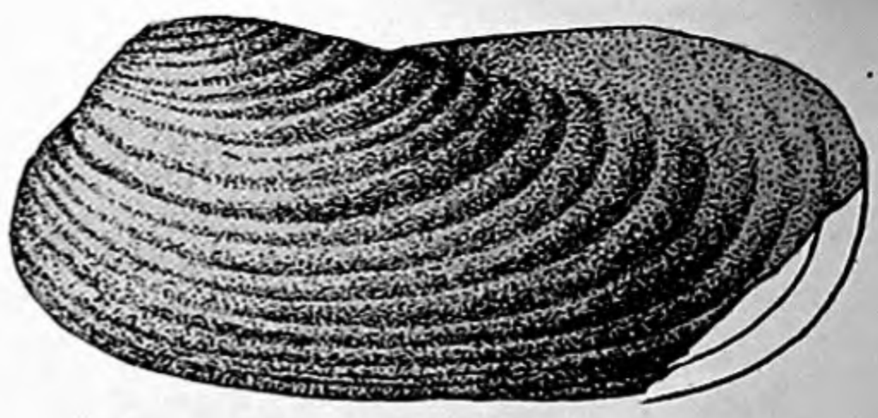

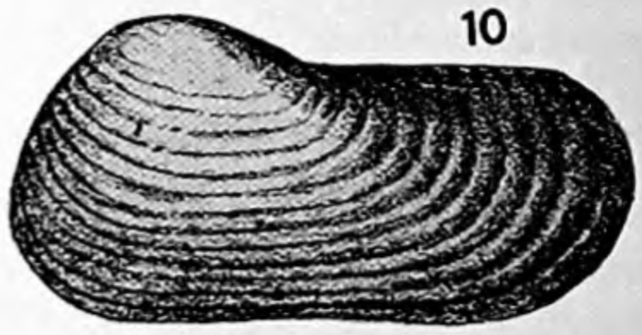

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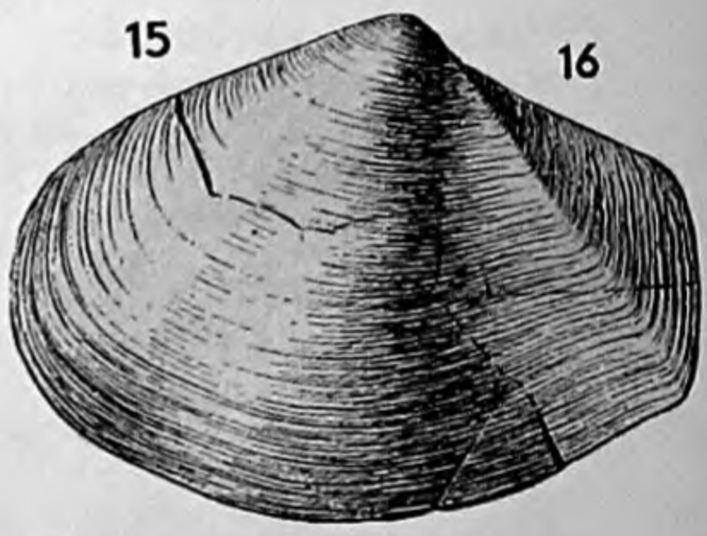

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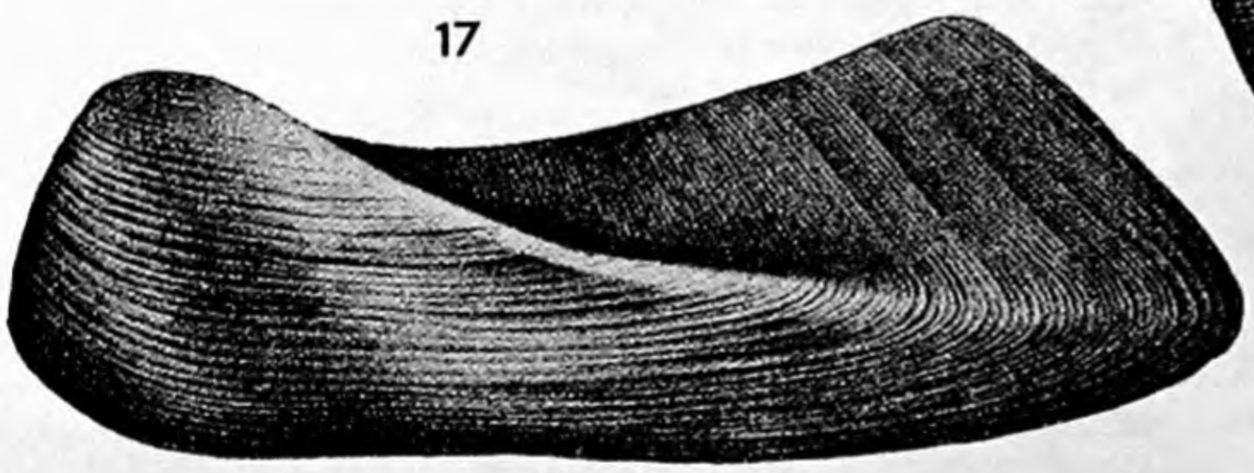

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phora beltula Billings) differs from *Goniophora* only in the possession of radiating striae.) **Sil., Dev.**

G. (*Cosmogoniophora) bellula Billings (**164—12**). **U. Sil.** (Stonehouse): N. S.

G. perangulata Hall and Whitfield (**164—14**). **Dev.** (Schoharie–Onondaga): Ont.; N. Y., Ohio, Nev.

G. hamiltonensis (Hall) (**164—13**). **Dev.** (Hamilton–Naples): N. Y. to Md., W. Va.

MYTILUS Linnaeus 1758

(**M. edulis*). Equivalve, very inequilateral, elongated, usually thin, with terminal pointed beaks; valves wider and rounded below, gaping a little for the byssus, usually smooth; a conspicuous epidermis and thin nacreous layer present; hinge with a few small teeth under beaks or lacking teeth; pallial line simple. **Trias.–Recent.**

M. conradinus Orbigny (**164—19**). Hinge with slightly prominent teeth. **Mioc.:** Atlantic and Gulf Coastal Plain, N. J. to Tex.

VOLSELLA Scopoli 1777

(= MODIOLUS Lamarck 1799)

(**Mytilus modiolus* Linnaeus). Like *Mytilus* but with umbos obtuse and anterior though not terminal; without teeth; anterior part of hinge is smooth and slightly reflected; valves inflated in front; epidermis rather hairy. **Dev.–Recent.**

V. (Brachydontes) multilinigera Meek (**164—16**). **U. Cret.** (Coloradoan): Kan. to Utah.

V. saffordi (Gabb) (**164—18**). Umbo and umbonal ridge more prominent than in *V. alabamensis*. **Paleoc.** (Midway): Tenn., Tex.

V. alabamensis (Aldrich) (**164—17**). **Eoc.:** Pamunkey of Md. and Va.; Jackson of Ga.

V. recta (Conrad) (= **V. directa** (Dall)) (**164—15**). Outline angular. **Olig.?:** Wash.; **Mioc.:** Wash., Ore., Cal.; **Plioc.–Recent:** Cal.

CRENELLA Brown 1827

(**C. decussata* Montagu). Shell small, ovoid; beaks incurved; surface bearing thin epidermis and fine radial striations. **Cret.–Recent.**

C. serica Conrad (**164—22–24**). **U. Cret.** (*Exogyra costata* zone): Atlantic and Gulf Coastal Plain.

C. elegantula Meek and Hayden (**164—20, 21**). **U. Cret.:** Monmouth of N. J., Md.; Ripley of Tenn. (Owl Creek), Miss.; Pierre of Western Interior and Rocky Mountain regions.

LITHOPHAGA Bolten 1798

(= LITHODOMUS Cuvier 1817)

(**L. mytuloides*). Shell thin, equivalve, strongly inequilateral, transversely elongate; umbos strongly anterior but not terminal; young attached by byssus, but later they usually perforate coral colonies or solid rock; cavities which they excavate are flask-shaped. **Penn.–Recent.**

L. carolinensis (Conrad) (**164—25–27**). **U. Cret.** (upper part of *Exogyra ponderosa* zone and *E. costata* zone): Atlantic and Gulf Coastal Plain.

DREISSENA Beneden 1835

(**Mytilus polymorphus* Pallas). Shell mytiliform in outline; umbos acute, terminal, bent slightly forward; angle between umbos bridged by transverse septum upon which anterior and pedal adductors are mounted; ligament more internal than in *Mytilus*. **Cret.–Recent.**

D.? tippana Conrad (**164—28–30**). **U. Cret.:** Matawan–Monmouth of Md.; Ripley and Providence of Ga., Ala.; Ripley and Owl Creek of Miss.

Order Anomalodesmacea. Siphons well developed, hence pallial sinus present; adductor muscle scars subequal; ligament usually opisthodetic, generally associated with chondrophores and lithodesma; dorsal margin without distinct hinge plate; dentition feeble or lacking; usually burrowing.

Superfamily ANATINACEA

PLEUROMYA Agassiz 1845

(**Mya gibbosa* Sowerby). Slightly inequivalve; posterior side the longer, somewhat gaping; hinge margin with a thin, horizontal lamina in each valve, the left inferior; margin with feeble notch behind lamina; individuals of same species quite variable. **Trias.–L. Cret.**

P. subcompressa Meek (**164—31, 32**). **U. Jura.:** Great Plains to Pacific Coast.

P. inconstans Castillo and Aguilera (**164—33**). Broad, shallow sinus usually present in anterior umbonal region; posterior end high. **U. Jura.:** Tex. (Malone); Mex.

PLATE 165

[Figures are x1 unless otherwise indicated.]

1, 2. Allorisma spp. 1. A. geinitzi [USGS Neb 1872 (Hayden)]. Left valve (x2). **2. A. costatum** [Kan G S 6]. Right valve. **3, 4. Sphenotus spp.** [Pal N Y 5]. **3. S. truncatus. 4. S. contractus.** Right valve. **5, 6. Rhytimya spp.** [Ohio G S 7]. **5. R. radiata.** Right valve. **6. R. producta.** Right valve. **7. Spathella typica** [Pal N Y 5]. Left valve. **8, 9. Pholadella radiata** [Pal N Y 5]. Right and left valves. **10–12. Allorisma spp.** [Kan G S 6]. **10, 11. A. terminale.** Dorsal view and left exterior. **12. A. granosum.** Left exterior. **13, 14. Endodesma cuneatum** [Minn G S 3 (2)]. Right side and dorsal view of the type, an internal filling. **15, 16. Pholadomya papyracea** [USGS Ter 9]. Left exterior and dorsal view of type. **17–19. Cimitaria spp.** [Pal N Y 5]. **17, 18. C. recurva.** Right valve and cardinal view. **19. C. angulata.** Left exterior. **20. Anatimya anteradiata** [Pal N J 4]. Left valve. **21, 22. Cymella bella** [NCGS 5]. Two views of a left valve. **23. Cymella undata** [USGS Ter 9]. Left valve of type. **24, 25. Thracia trapezoides** [USGS, PP 59]. Left valve; dorsal view. **26, 27. Cuspidaria spp.** [USGS Ter 9]. **26. C. ventricosa.** Left valve of type (x2). **27. C. moreauensis.** Right valve of type (x2). **28. Liopistha protexta** [Md G S, U Cret]. Left exterior. **29, 30. Clavagella armata** (x3) [USGS, PP 137]. Right exterior; anterior spinose collar. **31–36. Pleurophorus spp. 31. P. tropidophorus** [Kan G S 6]. Right valve. **32. P. oblongus** [USGS Neb 1872 (Hayden)]. Impression of right interior (x2). **33. P. subcostatus** [Kan G S 6; after Meek and Worthen]. Impression of left interior. **34. P. occidentalis** [USGS, B 77]. Right valve. **35, 36. P. albequus** (x3) [GSA, B 51]. Right valve of lectotype; interior of small right valve.

ALLORISMA King 1844

(**A. sulcatum* Fleming). Equivalve, inequilateral, elongate, thin, arcuate; anterior side short, posterior long and gaping; beaks anterior, depressed; sculpture concentric, strongest medially; hinge without teeth; ligament external; cardinal margin inflected, forming a lanceolate depression along its border behind beaks; posterior adductor scar large; pallial line sinuate. **Miss.–Perm.**

A. geinitzi Meek (**165**—1). Surface bearing fine radiating and concentric lines. **Penn.:** Ill., Kan.

A. costatum Meek and Worthen (**165**—2). **Penn.:** Ohio, Ill., Ia., Mo., N. Mex.

A. granosum Shumard (**165**—12). Beaks very prominent, incurved. **U. Penn.:** Mo., Kan.; **Perm.:** Kan.

A. terminale Hall (= **A. subcuneata** Meek and Hayden) (**165**—10, 11). **Penn.:** Pa. and Ala. to Utah.; **Perm.:** Kan., Colo., Wyo., Ariz.

NEWSOMELLA Foerste 1909

(**N. ulrichi*). On right valve besides the lamellose, concentric growth lines there are two systems of more or less radiating striations crossing each other at angles of about 30°; these are usually best seen along the umbonal ridge; teeth apparently absent. **M. Sil.**

***N. ulrichi** Foerste (**164**—34, 35). **Niagaran:** Tenn. (Waldron).

SPHENOTUS Hall 1885

(**Sanguinolites arcaeformis*). Entire shell almost cylindrical in shape; posterior end usually obliquely truncate; beaks very near anterior end, hinge line long and straight; valves marked by well defined umbonal ridge and broad sinus; hinge narrow, with two short teeth beneath the beak and with one or two slender lateral teeth; ligament external and contained in a slender groove along hinge line; two muscle impressions; pallial line simple; differs from *Sanguinolites* and *Allorisma* in the presence of teeth. **Dev., Miss.**

S. truncatus (Conrad) (**165**—3). **Dev.** (Hamilton–Ithaca): Que. (Gasspess); N. Y.

S. contractus (Hall) (**165**—4). **Dev.** (Canadaway–Conewango): N. Y., Md.

SPATHELLA Hall 1885

(**S. typica*). Shell subcylindrical; concentric growth lines lamellose; no radiating striae. **Dev.**

***S. typica** Hall (**165**—7). **Dev.** (Naples–Canadaway): N. Y., Pa.

RHYTIMYA Ulrich 1893

(**R. producta*). Shell very thin, elongate, gaping slightly at both ends; hinge and basal margin subparallel; beaks prominent; mesial furrow wide; ligament external; hinge apparently without teeth; muscle scars faint; surface bearing concentric folds, strongest anteriorly, crossed on posterior half by radiating rows of small granules. **Ord.**

R. radiata Ulrich (**165**—5). Mesial furrow slightly developed; posterior half of shell with radiating lines. **U. Ord.** (Eden): Que.; Cincinnati region.

***R. producta** Ulrich (**165**—6). **U. Ord.** (Maysville): Fairmount of Cincinnati region.

ENDODESMA Ulrich 1894

(**E. cuneatum*). Shell very thin, equivalve, convex, elongate; hinge and basal margins subparallel; mesial depression deep; umbos compressed, elevated; hinge thin, apparently without teeth; a flattened area (lunule) present in front of beaks; surface bearing concentric lines; muscle scars very faint. **Ord.**

***E. cuneatum** Ulrich (**165**—13, 14). **Ord.** (Galena): Minn.

PHOLADELLA Hall 1869

(**P. newberryi*). Transversely elongate, with truncate posterior end and rounded or obliquely truncate anterior end; beaks anterior to middle and prominent; umbonal slope prominent; surface bearing fine concentric striae, often becoming strong undulations, and, on the body of the shell, with distinct radii which are absent from the anterior end and cardinal slope; ligament external. **Dev.**

P. radiata (Conrad) (**165**—8, 9). **Dev.** (Hamilton): N. Y., Pa., Md.; persisting at times into Ithaca.

CIMITARIA Hall 1869

(**Cypricardites recurva* Conrad). Very elongate, with anterior and strongly incurved beaks, short and rounded anterior end and long and truncate posterior; umbonal slope well defined; surface crossed by strong concentric growth lines and marked by very fine radial striae and by a depression extending somewhat posteriorly from beaks to base; lunule present; ligament external; hinge without teeth. **Dev.**

***C. recurva** (Conrad) (**165**—17, 18). **Dev.** (Hamilton–Tully): N. Y., Pa., Wis.

C. angulata Hall (**165**—19). **Dev.** (Chemung): N. Y.

PHOLADOMYA Sowerby 1823

(**P. candida*). Shell thin, translucent, subovate, equivalve, gaping posteriorly and sometimes anteriorly; anterior side short, rounded; surface bearing radiating ribs (feeble in posterior dorsal region), crossed by concentric striae; umbos prominent; ligament external; hinge without teeth or with an obscure thickening; adductor scars feeble; pallial sinus deep; species very similar. **Jura.–Recent.**

P. papyracea Meek and Hayden (**165**—15, 16). **U. Cret.:** Benton of Kan., Mont., N. Mex.; Niobrara of Wyo.

ANATIMYA Conrad 1860

(**Pholadomya anteradiata*). Oblong; anterior side with concentric sculpture; posterior with concentric and radiating ribs. **Cret.**

***A. anteradiata** Conrad (**165**—20). Beaks scarcely elevated above hinge line, pointing posteriorly; valves depressed-convex; margins subparallel. **U. Cret.:** N. J. (Woodbury, Wenonah), Ala. (Ripley), Miss. (Owl Creek).

THRACIA Leach 1823

(**T. corbuloidea*). Shell inequivalve, thin, without teeth, with pallial sinus; surface smooth or concentrically striated, with granular surface; usually more or less rostrate. **Trias.–Recent.**

T. trapezoides Conrad (**165**—24, 25). **Mioc.:** Wash., Ore.; **Plioc.:** Ore., Cal.; **Pleist.:** Cal.; **Recent:** Wash. to Alaska.

Superfamily ENDOSIPHONACEA

LIOPISTHA Meek 1864

(**Cardium elegantulum* Roemer). Equivalve, oval, thin, inflated; valves gaping and compressed posteriorly; entire surface of valves, except posterior dorsal portions, with numerous strong, radial ribs; beaks prominent, incurved; hinge inflected along its entire length; cardinal teeth two, projecting directly outward from beneath beaks; ligament sunken, partly external. **U. Cret.**

L. protexta (Conrad) (**165**—28). **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

CYMELLA Meek 1864

(**Pholadomya undata* Meek and Hayden = *C. montanensis* Henderson). Differs from *Liopistha* in having concentric surface undulations; these are crossed only on the middle portion of valves by impressed lines. **U. Cret.**

***C. montanensis** Henderson (= **C. undata** (M. and H.)) (**165**—23). Umbos less prominent and radii finer than in the closely related *C. bella*. **U. Cret.:** Montanan throughout the Rocky Mountain region.

C. bella (Conrad) (**165**—21, 22). **U. Cret.:** Atlantic and Gulf Coastal Plain to Tex.; S. Dak.

CUSPIDARIA Nardo 1840

(**Tellina cuspidata* Olivi). Hinge without teeth, but with a small, internal, posteriorly inclined resilifer in each valve and an elongated ridge behind it; ligament subinternal, anterior to beaks or obsolete; pallial line simple; surface concentrically sculptured. **Jura.–Recent.**

C. ventricosa Meek and Hayden (**165**—26). **U. Cret.:** N. J. (Wenonah–Tinton); Montanan: N. and S. Dak., Mont.

C. moreauensis Meek and Hayden (**165**—27). Distinguished from *C. ventricosa* by its regular, concentric ribs, instead of more concentric striae. **U. Cret.** (Montanan): Sask.; S. Dak., Mont.

CLAVAGELLA Blainville 1817

(**C. echinata?*). Shell degenerate, specialized for burrowing by development of calcareous tube which is fringed anteriorly by tubular spines; in adults the right valve is not attached to the tube. **Cret.–Recent.**

C. armata Morton (**165**—29, 30). Left valve surrounded by several spines. **U. Cret.:** N. J. (Monmouth), Tenn. and Ala. (Ripley).

Order Teleodesmacea. Siphons usually developed; adductor muscles practically equal; shell structure porcelaneous, never nacreous; dorsal area if present always divided into lunule and escutcheon; nepionic stage usually with taxodont hinge line; permanent dentition with distinct cardinals and laterals, usually placed upon a distinct hinge plate; rarely burrowing.

Superfamily CYPRICARDIACEA

PLEUROPHORUS King 1844

(**Arca costata* Brown). Inequilateral, elongate, rectangular with beaks nearly terminal; a single cardinal tooth present in each valve and one posterolateral tooth in right valve fitting into socket of left valve; anterior muscle scar deep, bounded posteriorly by a ridge; pallial line simple. **Dev.–Trias.**

P. tropidophorus Meek (**165**—31). Posterior slope doubly angular with two ridges that pass obliquely backward from the beaks. **Penn.:** Ohio, Mo. **L. Penn.:** Ark., Okla.; Alta.

P. oblongus Meek (**165**—32). **Penn.:** Ill., Mo., Ark., Neb.

P. subcostatus Meek and Worthen (**165**—33). Surface covered with fine growth lines and with three to four radii extending from beak to posterior margin. **Penn.:** Ohio to Colo.

P. occidentalis Meek and Hayden (**165**—34). With radiating ridges extending from beak to posterior margin. **Penn.:** Neb., Colo. **Perm.:** Neb., Kan., Tex., N. Mex.

P. albequus Beede (**165**—35, 36). Differs from *P. occidentalis* in being larger, and in having an arcuate hinge, and from *P. oblongus* in being proportionally much longer and in possessing radiating ridges. **Perm.:** Okla. and Tex. (Whitehorse), N. Mex. (Carlsbad).

CYPRICARDELLA Hall 1858

(**C. subelliptica*). Equivalve, inequilateral, subquadrate, with straight or nearly straight hinge line; anterior end narrow and rounded; posterior end longer, broad, and truncate; beaks small, appressed; umbonal ridge more or less defined, extending backward from beaks; surface bearing lamellose concentric striae; hinge with a triangular tooth in each valve and corresponding sockets; there is also in the right valve a longer triangular fold or lateral tooth; ligament external, extending nearly or entirely the length of hinge line. **Dev.–Miss.**

C. complanata Hall (**166**—1). **Dev.** (L. Hamilton): N. Y.

C. tenuistriata (Hall) (**166**—2). **Dev.** (Hamilton–Conneaut): N. Y. to Md.

C. gregaria (Hall) (**166**—3). **Dev.** (Hamilton–Conneaut): N. Y. to Md.

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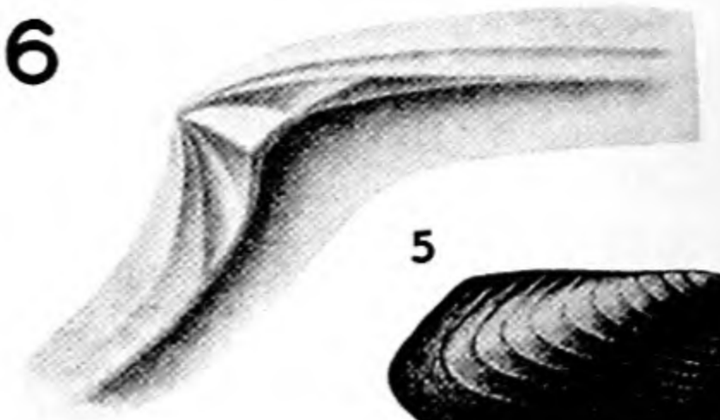

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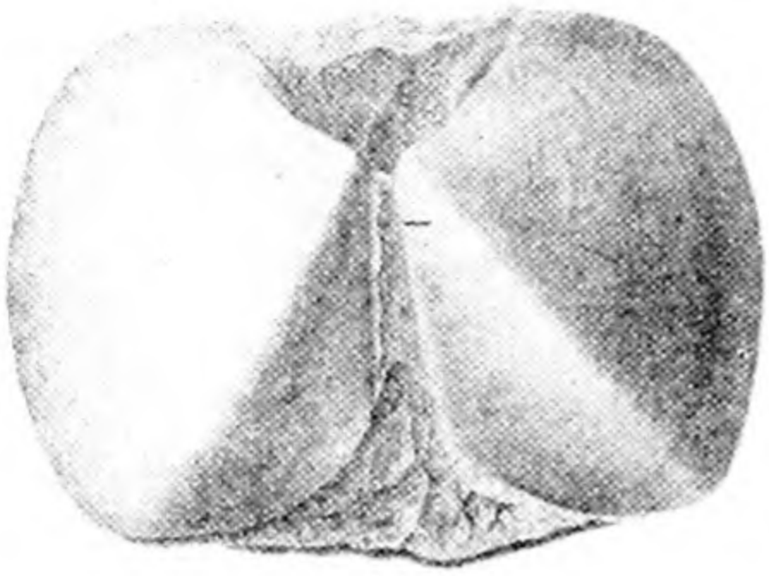

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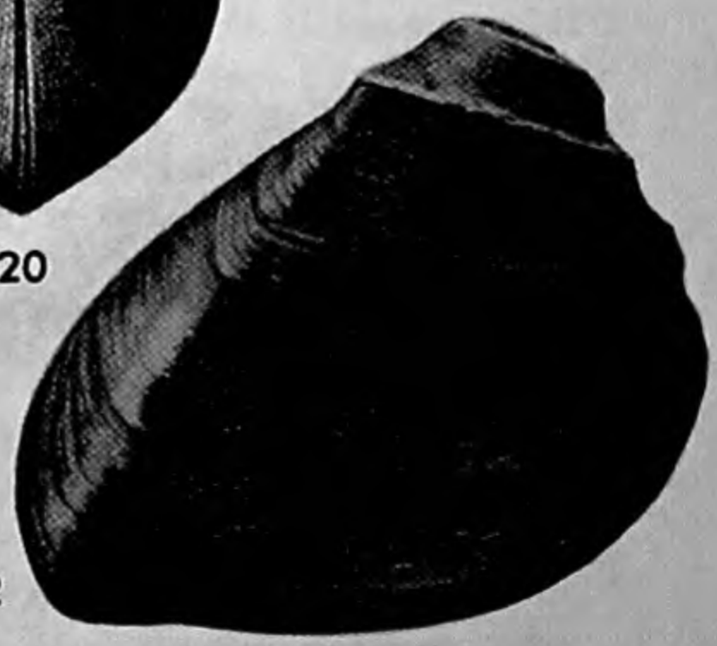

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C. bellastriata (Conrad) (**166**—4, 5). **Dev.:** Northern Appalachian region (Marcellus–Chemung); N. Y. to Md. (Marcellus–Hamilton).

C. oblonga Hall (**166**—6). **Miss.:** Ohio (Maxville), Ind. (St. Louis), Ky. (Ste. Genevieve), Ark. (Batesville).

CYPRICARDINIA Hall 1859

(**C. lamellosa*). Inequivalve, with more convex right valve, somewhat rhomboidal or trapezoidal; anterior end short and rounded; posterior wider and obliquely truncate; beaks nearly at anterior extremity; umbonal slope prominent; surface bearing concentric lamellose ridges with intermediate fine growth striae and in some species radial striae; two to three cardinal teeth present; ligament external; pallial line simple; shell thicker than in *Modiolopsis* and concentric striae stronger. **Sil.–Miss.**

C. arata Hall (**166**—13). Surface crossed by strong concentric lamellose ridges. **Sil.** (Niagaran): Waldron of Ind., Tenn.; Racine of Wis., Ill.

***C. lamellosa** Hall (**166**—11, 12). **Dev.** (Helderbergian): N. Y. (New Scotland), W. Va.; found also in Oriskany.

C. indenta Conrad (**166**—10). **Dev.** (Onondaga–Hamilton): Ont.; N. Y. to Va., Ky.

C. consimilis Hall (**166**—8, 9). **L. Miss.** (Waverly): Pa., Ohio.

C. carbonaria Meek (**166**—7). Surface bearing 15 to 20 flattened, subimbricating concentric ridges. **Penn.:** Ohio, Mo., Kan., Colo.

ASTARTELLA Hall 1858

(**A. vera*). Shell thick, smooth or concentrically furrowed; a single, large cardinal tooth present in each valve; anterior part of cardinal margin of left valve forms a linear tooth that is received by a groove in the thickened margin of right valve; on posterior part of cardinal margin the linear tooth is in right valve and groove in left valve; lunule and escutcheon sharply defined. **Penn.–Trias.?**

***A. vera** Hall (**166**—15). **Penn.:** Ohio to Okla., Ala., Tex.

A. newberryi Meek (**166**—14). **Penn.:** Ohio, Ark., Okla.

ARCTICA Schumacher 1817

(= CYPRINA Lamarck 1818)

(**Venus islandica* Linnaeus). Orbicular or oval, inflated, with thick epidermis; beaks prominent, incurved; lunule absent; three cardinal and one ridge-like posterior lateral in each valve, the middle cardinal of left valve the largest; surface concentrically striated; valve margins smooth; ligament external and prominent; pallial line simple. **Jura.–Recent.**

A. occidentalis (Whiteaves) (**166**—18). **U. Jura.?:** Alta.; **L. Cret.:** Cal. (Paskenta); B. C. (Queen Charlotte).

A. ovata (Meek and Hayden) (**166**—16, 17). **U. Cret.:** N. Dak. (Lance). Varieties have been reported from the Montanan of Sask., Alta., and Mont.

VENIELLA Stoliczka 1870

(**Venilia conradi* Morton). Very similar to *Arctica*, but left valve has anterior cardinal teeth strong and subtriangular and the posterior umbonal slope is more or less pronounced. **Cret.–Tert.**

***V. conradi** (Morton) (**166**—21, 22). **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

V. humilis Meek and Hayden (**166**—19, 20). **U. Cret.** (Fox Hills): S. Dak., Wyo., Colo.

ETEA Conrad 1875

(**E. carolinensis*). Shell very oblique and inequilateral; lacks crenulations on inner free margins of valves; has two cardinal teeth, an elongate anterior and a posterior lateral tooth in each valve; the anterior cardinal of left valve is triangular, fitting into a triangular pit of right valve between the two cardinal teeth of the valve. **Cret.**

***E. carolinensis** Conrad (**166**—23, 24). **U. Cret.** (*Exogyra ponderosa* zone): Matawan of N. J., Del., Md.; Blufftown and Cusseta of Ga., Ala.; Coffee of Miss.

Superfamily ASTARTACEA

ASTARTE Sowerby 1816

(**A. lurida*). Shell thick, inequilateral, usually rounded triangular or oval, closed, with smooth or concentrically sculptured exterior; epidermis thick; lunule impressed, escutcheon elongate; two cardinal teeth present in each valve, the right anterior strong; lateral teeth rudimentary; adductor scars strong, nearly equal; above the anterior is a pedal impression; pallial line simple. **Trias.–Recent.**

A. packardi White (**166**—27, 28). **U. Jura.:** Wyo. (Sundance), Idaho (Twin Creek).

A. trapezoidalis Stanton (**166**—25, 26). **L. Cret.:** Cal. (Paskenta).

PLATE 166

[Figures are x1 and after Hall [Pal N Y 5] unless otherwise indicated.]

1–6. Cypricardella spp. 1. C. complanata. Left valve. **2. C. tenuistriata.** Valves in conjunction. **3. C. gregaria.** Left valve. **4, 5. C. bellastriata.** Left valve; hinge of right valve enlarged. **6. C. oblonga** [Ind G S 12]. Right valve of type (x2). **7–13. Cypricardinia spp. 7. C. carbonaria** [Kan G S 6]. Left valve. **8, 9. C. consimilis.** Right side and cardinal views of a filling. **10. C. indenta.** Right valve. **11, 12. C. lamellosa** [Pal N Y 3]. Cardinal view and left exterior (x3). **13. C. arata** [Ind G S 11]. Interior of compressed left valve showing concentric ridges. **14, 15. Astartella spp. 14. A. newberryi** [Pal Ohio 2]. Left valve. **15. A. vera** [Kan G S 6]. **16–18. Arctica spp. 16, 17. A. ovata** [USGS, PP 128]. Views of type, a small right valve. **18. A. occidentalis** [USGS, B 133]. Right exterior. **19–22. Veniella spp. 19, 20. V. humilis** [USGS Ter 9]. Left side and anterior views of type. **21, 22. V. conradi** [USGS, PP 137]. Anterior view of combined valves; right exterior. **23, 24. Etea carolinensis** [NCGS 5]. The type, a left valve; a right interior. **25–28. Astarte spp. 25, 26. A. trapezoidalis** [USGS, B 133]. Right side and cardinal views of type. **27, 28. A. packardi** [USGS, PP 152]. Left exterior; side view of combined valves.

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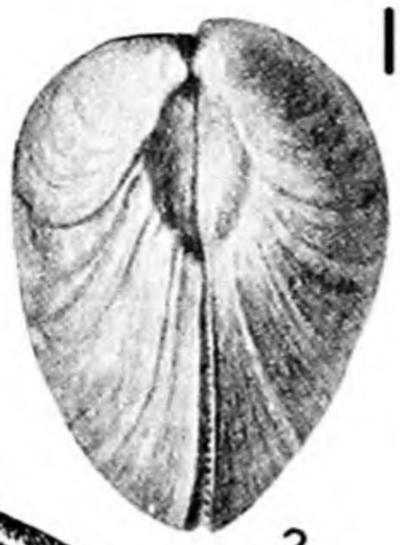

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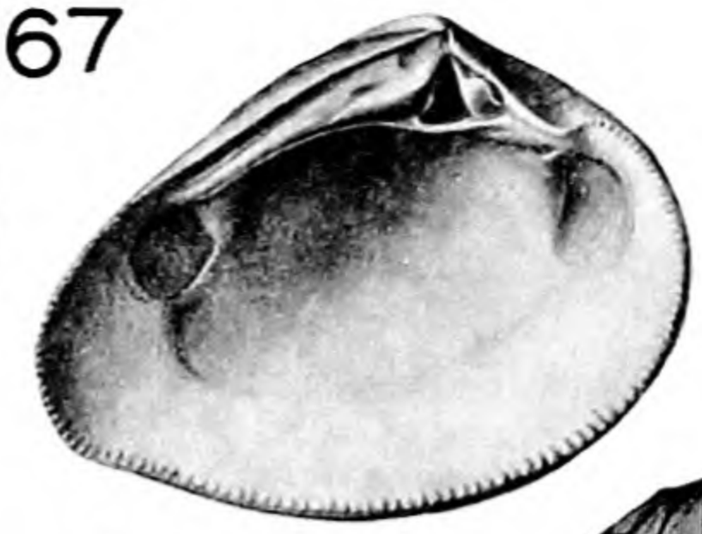

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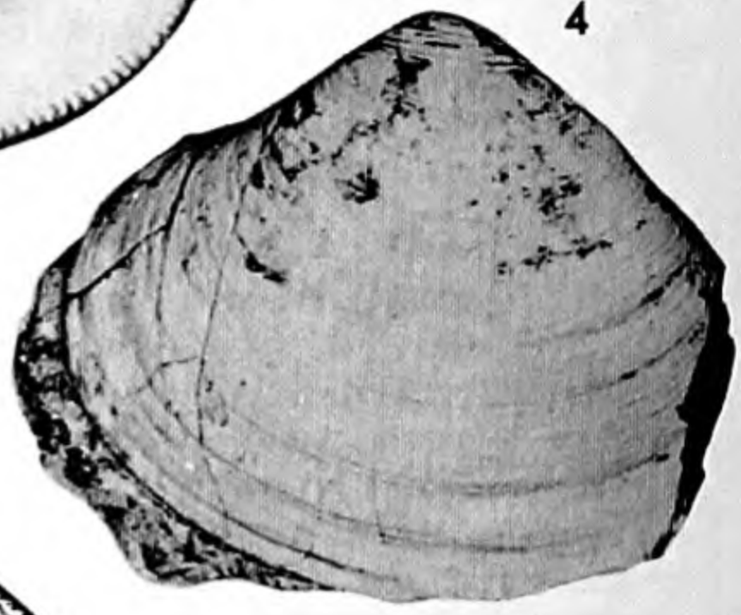

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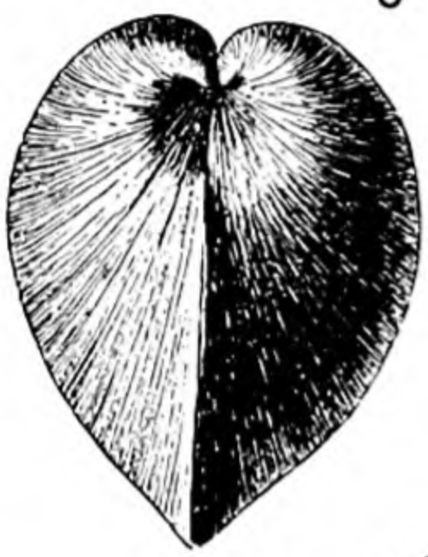

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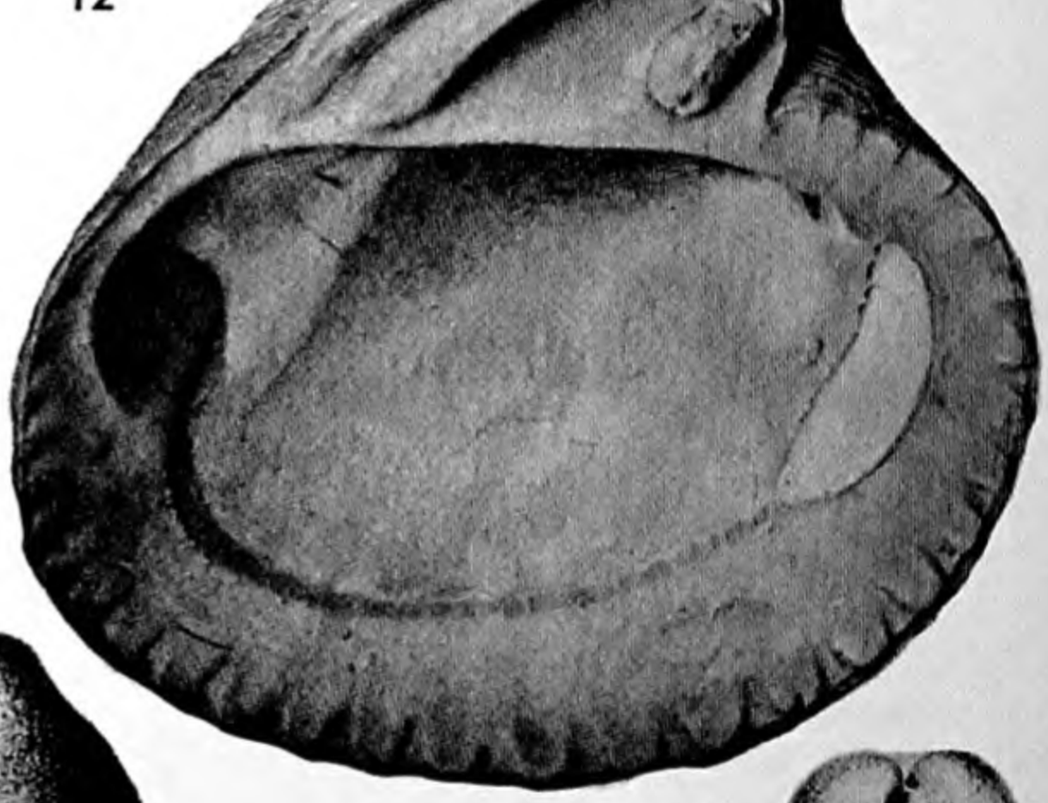

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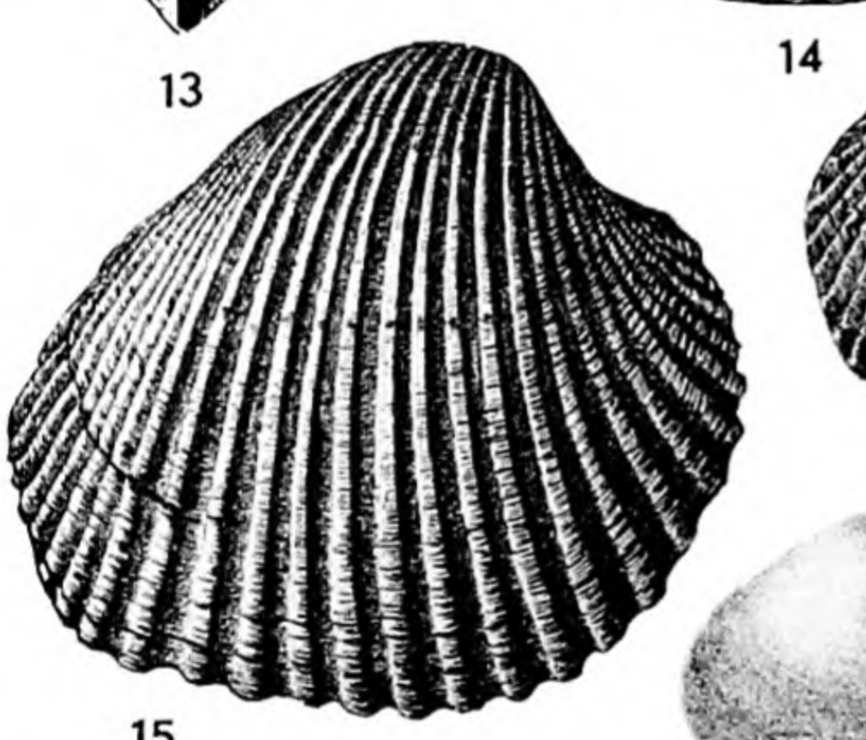

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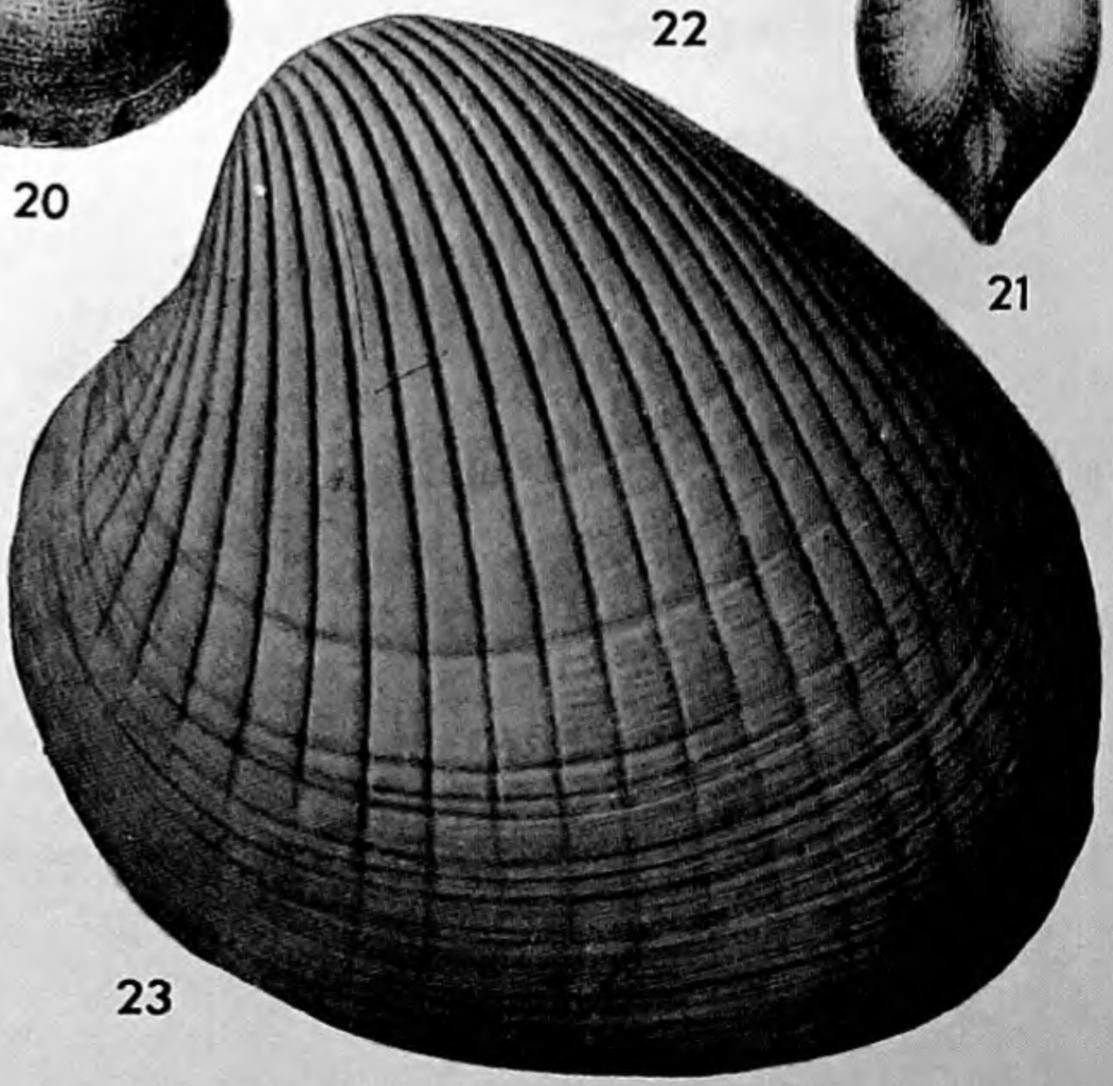

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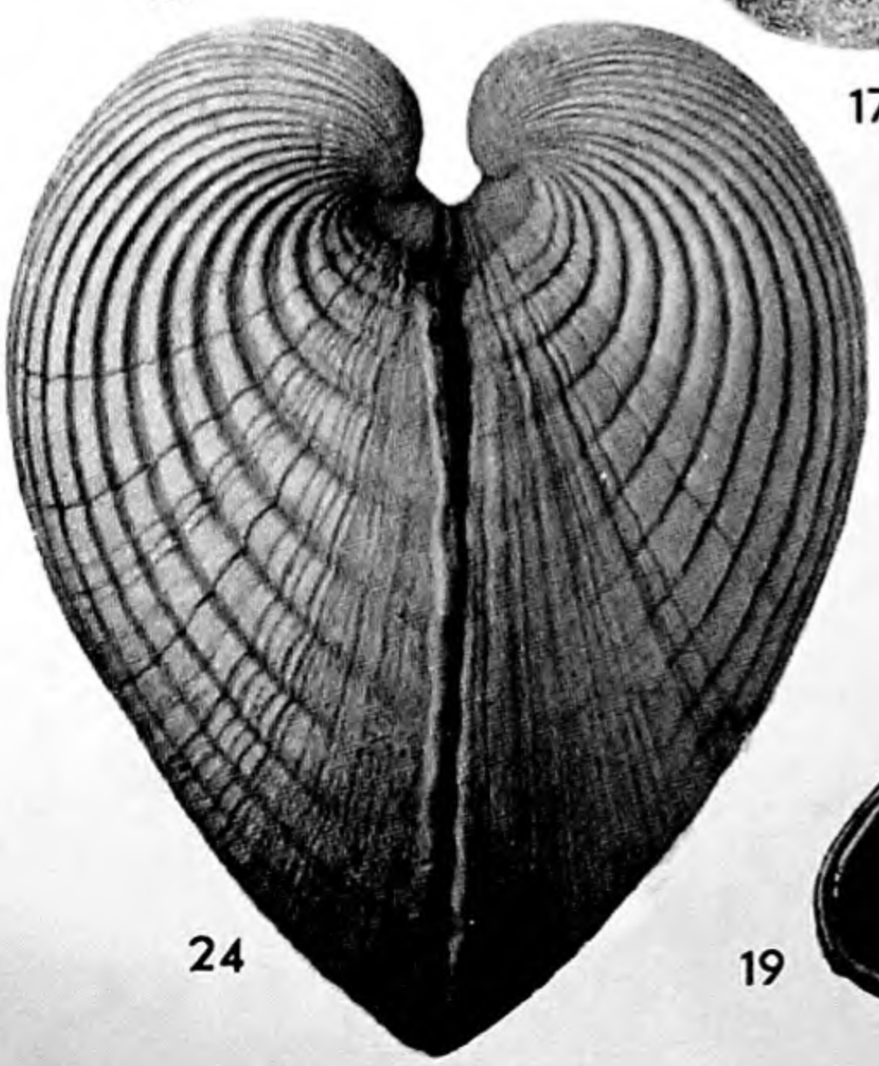

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CRASSATELLITES Krueger 1823

(= CRASSATELLA of some authors)

(**Crassatella sinuata* Lamarck). Shell solid, somewhat attenuated behind; umbos small, close together; lunule distinct; resilifer present beneath umbo; hinge plate heavy, flat, with two cardinal teeth in each valve; lateral teeth present; free margins of valves crenate in some species; adductor impressions deep; pallial line simple. **U. Cret.–Recent.**

C. vadosus (Morton) (**167**—1–3). *C. linteus* (Conrad) is probably the young of this species. **U. Cret.** (*Exogyra costata* zone): Atlantic and Gulf Coastal Plain.

C. pteropsis (Conrad) (**167**—4). **U. Cret.** (Ripley and equivalents): Atlantic and Gulf Coastal Plain.

C. gabbi (Safford) (**167**—5). **Paleoc.** (Midway): Gulf Coastal Plain.

C. uvasana (Conrad) (**167**—11). Outline subtriangular; length and breadth about equal. **U. Eoc.** (Tejon): Wash. to Cal.

C. halei Harris (**167**—12). **Eoc.** (Wilcox): Ga., Ala.

SCAMBULA Conrad 1869

(**S. perplana*). Hinge with two equal teeth in right valve, posterior one direct and ending at apex; a long anterior double tooth parallel with straight cardinal line; anterior muscle impression small, rounded. **Cret.**

***S. perplana** Conrad (**167**—6, 7). Characterized by flatness on disk, ventral margin carinated anteriorly, and inner valve surface granulated. **U.Cret.:** N. J. (Matawan), Tenn. (Coon Creek), Ga. (Ripley), Ala. (Blufftown), Miss. (Owl Creek), Tex. (Corsicana).

Superfamily CYRENACEA

CORBICULA Megerle 1811

(**Tellina fluminalis* Müller). Shell porcelaneous, rounded-trigonal, ventricose, with conspicuous epidermis and marked by concentric growth lines, margins smooth; pallial line simple or with slight sinus; ligament prominent, external; adductor scars nearly equal; hinge with anterior and posterior laterals distinctly separated from the cardinals and smooth or cross striated; cardinal teeth bifid at summit and usually three in each valve; brackish water dwellers. **Cret.–Recent.**

C. durkeei (Meek) (**167**—13, 14). **U. Cret.** (Bear River): Southwestern Wyo. and adjacent parts of Utah and Idaho.

C. occidentalis (Meek and Hayden) (**167**—20, 21). Estuarine. **U. Cret.** (Judith River to Lance): Sask., Alta.; N. and S. Dak., Mont., Wyo., Colo.

C. cytheriformis (Meek and Hayden) (**167**—17–19). Estuarine. **U. Cret.** (Edmonton, Judith River, Lance, Mesaverde, etc.): Alta. to Colo. (doubtfully), N. Mex. and Mex.

SPHAERIUM Scopoli 1777

(**Tellina cornea* Linnaeus). Small, thin, inflated, rounded; sculpture concentric, never strong; cardinal teeth usually two in each valve, variable, thin, often nearly parallel to hinge line or in part defective; lateral teeth compressed, lamelliform, anterior the shortest; ligament short and feeble, deep-set in a groove; muscle impressions near margin and scarcely apparent; pallial line simple; fresh and brackish water dwellers. **Cret.–Recent.**

S. planum Meek and Hayden (**167**—10). **U. Cret.:** Judith River and Belly River of Neb., Mont., Wyo.; Sask., Alta.; Lance of Mont., Wyo.

S. formosum Meek and Hayden (**167**—8, 9). **U. Cret.–L. Eoc.:** Belly River and Edmonton of Sask., Alta.; Mont., Wyo.; Fort Union of Mont. In the Paskapoo of Sask. and Alta. occurs the variety **whiteavesi** Dussell.

Superfamily CARDITACEA

VENERICARDIA Lamarck 1801

(**Venus imbricata*). Shell rounded or cordate, inequilateral, with radiating ribs; umbos prominent; basal margin crenulated internally; ligament external; hinge thick without lateral teeth but with posterior cardinal much prolonged; adductor impressions unequal; pallial line simple. **Cret.–Recent.**

V. (Venericor) smithi Aldrich (**167**—15). Ribs flat on central part of shell, tuberculated on anterior and posterior portions. **Paleoc.** (Midway): Gulf Coastal Plain.

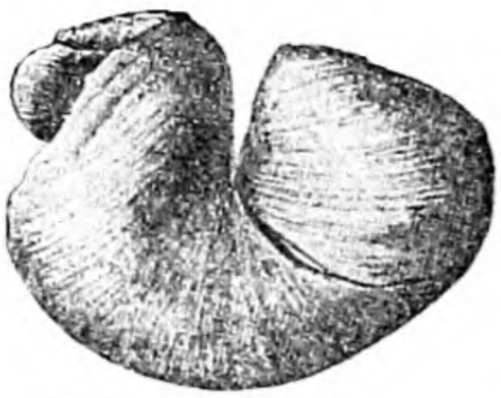
V. alticosta Conrad (**167**—16). Ribs much elevated and nodulose, those on anterior side are laterally keeled. **Eoc.** (Claiborne–Jackson): Ga., Ala., La., Cal. (Tejon).

V. (Venericor) planicosta Lamarck (**167**—22–24). The variety **claiboplata** Gardner and Bowles (**167**—22) is present in the Claiborne of S. C. to Tex.; var. **hornii** (Gabb) has rounded ribs and is recorded from the Tejon of Wash. to Cal. **Eoc.:** Aquia of Md.; Wilcox–Jackson of Ga. to Tex.; Martinez–Tejon of Alaska to Cal. One of the most characteristic and widespread **Eoc.** fossils in the world.

PLATE 167

[Figures are x1 unless otherwise indicated.]

1–5. Crassatellites spp. **1–3. C. vadosus** [Md G S, U Cret]. Left exterior; anterior view of shell; left interior. **4. C. pteropsis** [Md G S, U Cret]. Right exterior. **5. C. gabbi** [B Am Pal 4]. Left exterior of type. **6, 7. Scambula perplana** [USGS, PP 137]. Two views of a left valve (x3). **8–10. Sphaerium** spp. [USGS Ter 9]. **8, 9. S. formosum.** Right side and cardinal views of type (x3.5). **10. S. planum.** Left exterior of type. **11, 12. Crassatellites** spp. **11. C. uvasana** [Ac N Sc Phila, SP 3]. Left valve. **12. C. halei** [B Am Pal 9]. Right interior. **13, 14 Corbicula durkeei** [USGS, B 128]. Front and left side views. **15, 16. Venericardia** spp. [B Am Pal 4]. **15. V. (Venericor) smithi. 16. V. alticosta. 17–21. Corbicula** spp. [USGS Ter 9, except 19]. **17–19. C. cytheriformis.** Right valve and posterior view of type; left interior [USGS, PP 128]. **20, 21. C. occidentalis.** Right side and anterior view of type (latter too acuminate below because of distortion). **22–24. Venericardia (Venericor) planicosta** [USGS, PP 189]. **22. V. (V) planicosta claiboplata.** Left interior. **23, 24. V. (V) planicosta.** Front and left exterior views.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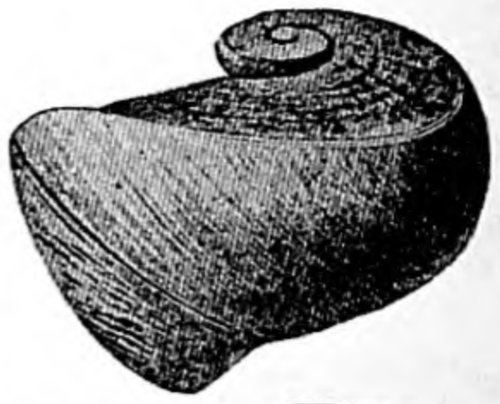
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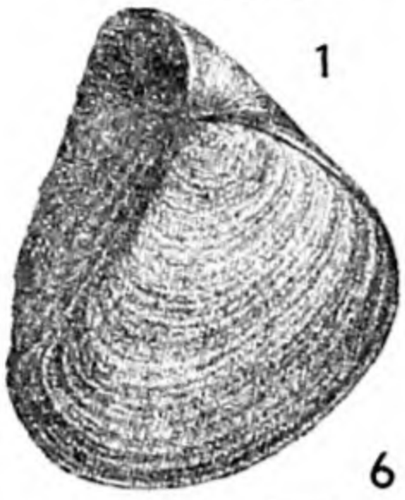
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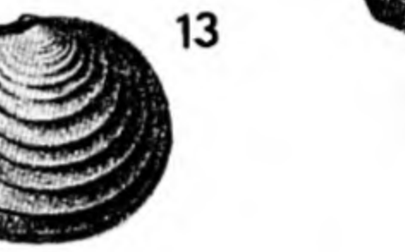
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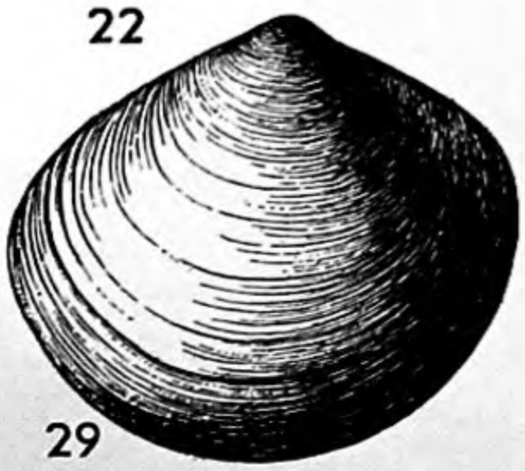
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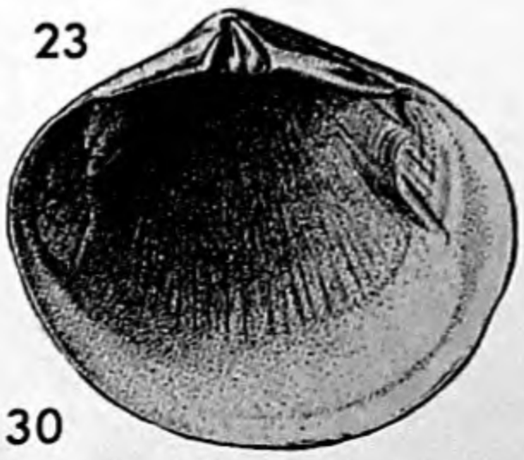
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Superfamily CHAMACEA

TOUCASIA Munier-Chalmas 1873

(**Requienia carinata* Matheron). Usually very inequivalve, attached by umbo of left valve, which is spiral and has a deep cavity; right valve smaller, somewhat spiral or flat; both valves keeled; teeth feeble; ligament external; posterior adductor scar bordered by a prominent, subspiral ridge in each valve. **L. Cret.**

T. patagiata (White) (= **Requienia patagiata** of authors) (**168**—1, 2). Beak of left valve distorted by attachment. **L. Cret.** (Fredericksburg): Tex.; Mex.

T. texana (Roemer) (**168**—3–5). **L. Cret.:** Fredericksburg of Tex. and Mex.; Trinity and Washita of N. Mex.

MONOPLEURA Matheron 1843

(**M. imbricata?*). Very inequivalve, smooth or ribbed, attached by right valve, which may be either twisted or coniform; left valve conical or flat; dentition consists of two cardinals in free valve and one in attached; ligament external in a deep groove; posterior adductor scar buttressed; shell substance without canals; shell often found in groups adhering laterally. **L. Cret.** (southern N. America, southern Europe).

M. texana Roemer (**168**—6, 7). Right valve low, conical, with angular umbonal ridge; left, gently convex. **L. Cret.** (Fredericksburg): Tex.; Mex.

M. pinguiscula White (**168**—8). Individuals apparently grew separately. **L. Cret.** (Fredericksburg): Tex.; Mex.

M. marcida White (**168**—9, 10). Surface of both valves bearing numerous raised radiating lines besides the concentric growth lines; individuals often grew in clusters. **L. Cret.:** Tex. (U. Fredericksburg). Italy.

CAPRINA Orbigny 1822

(**C. adversa*). Very inequivalve, attached by coniform right valve, which bears only growth lines and possesses an almost internal ligament groove; hinge margin with several deep cartilage pits and with one large posterior tooth; left valve large, spirally twisted; anterior tooth supported by a plate which divided umbonal cavity lengthwise, posterior teeth obscure; inner layer of lower (right) valve made up of concentric lamellae between which cavities are sometimes left; middle layer of free valve traversed by numerous simple, wide, parallel canals, extending from margin to apex; a series of depressions present between posterior adductor scar and margin. **Cret.**

C. occidentalis Conrad (**168**—11, 12). **L. Cret.** (Fredericksburg): Tex., N. Mex.

CORALLIOCHAMA White 1885

(**C. orcutti*). Shell a large cone, fixed by apex of lower (right) valve growing separately or in clusters, thick, of three layers, the outer prismatic, the middle cellular, and the inner porcelaneous; lower valve irregularly conical, somewhat distorted, upper convex with broad incurved beak; hinge similar to *Ichthyosarcolites*. **U. Cret.**

***C. orcutti** White (**168**—17–19). **U. Cret.:** Early Chico of Cal. and L. Cal.

Superfamily RUDISTACAE (RUDISTAE)

RADIOLITES Lamarck 1801

(**Ostracites angeiodes* Picot de Lapeirouse). Lower valve conical, erect, elongate, vertically ribbed or made up of successive layers; usually with two somewhat smooth bands extending from apex to upper margin, probably marking position of siphon openings; outer layers very thick, composed of large, polygonal cells or hollow prisms; upper valve operculumlike, flat, or conical, with central or eccentric umbo; teeth not forming hinge but specially modified for vertical motion of operculumlike valve; they consist of two sockets near outer wall of fixed (larger) valve; next to and outside sockets are two large, unequal, slightly excavated muscle scars into which fit two broad projecting muscle plates from the upper valve; pallial line simple, inclosing whole cavity. **Cret.**

R. (Eoradiolites) davidsoni Hill (**168**—16). **L. Cret.:** Tex. (U. Fredericksburg); Mex.; Egypt; Persia.

Superfamily LUCINACEA

TANCREDIA Lycett 1850

(**T. donaciformis* Lycett). Trigonal, usually with nearly equal beaks, but anterior side attenuated and somewhat the longer, and posterior wider,

PLATE 168

[Figures are x1 unless otherwise indicated.]

1–5. Toucasia spp. [USGS, B 4]. **1, 2. T. patagiata.** Different views of a specimen with both valves (x0.6). **3–5. T. texana.** Upper view of left valve; lateral view of valves joined; upper view of a small right valve. **6–10. Monopleura** spp. [USGS, B 4 except 6, 7]. **6, 7. M. texana** [Roemer: Kreidebild von Tex]. View of shell showing both valves; left exterior. **8. M. pinguiscula.** A large specimen showing both valves. **9, 10. M. marcida.** Two specimens with both valves. **11, 12. Caprina occidentalis** [Meek: Mex Bound Surv]. Left valve and its cross section (x0.5). **13–15. Paracyclas** spp. [Pal N Y 5]. **13. P. ohioensis.** Right valve. **14. P. lirata. 15. P. elliptica.** Left exterior. **16. Radiolites (Eoradiolites) davidsoni** [Biol Soc Wash, Pr 8]. Upper half of lower valve (x0.5). **17–19. Coralliochama orcutti** (x0.5) [USGS, B 22]. A complete adult specimen with both valves; a small section of the upper valve; cross section of lower valve showing outer prismatic layer, inner porcellaneous layer, and middle cellular layer. **20, 21. Tancredia** spp. **20. T. americana** [USGS Ter 9]. Right valve. **21. T. bulbosa** [U Kan Quart 9]. Right valve. **22–28. Lucina** spp. **22, 23. L. occidentalis** [USGS Ter 9]. Dorsal and right side views of an adult specimen. **24. L. smithi** [Md G S, Eoc]. Left exterior (x7). **25. L. (Lucinoma) acutilineata** [USGS, B 398]. Left exterior. **26, 27. L. curta** (x4) [Md G S, Eoc]. Left exterior of type; left interior. **28. L. subundata** [USGS Ter 9]. Left valve showing dorsal sulcus. **29–33. Taras** spp. **29, 30. T. acclinis** [Md G S, Mioc]. Exterior and interior of right valve (x1.5). **31, 32. T. hopkinsensis** [Md G S, Eoc]. Right valve (x2.5) and hinge enlarged. **33. T. parilis** [USGS, B 398]. Right valve.

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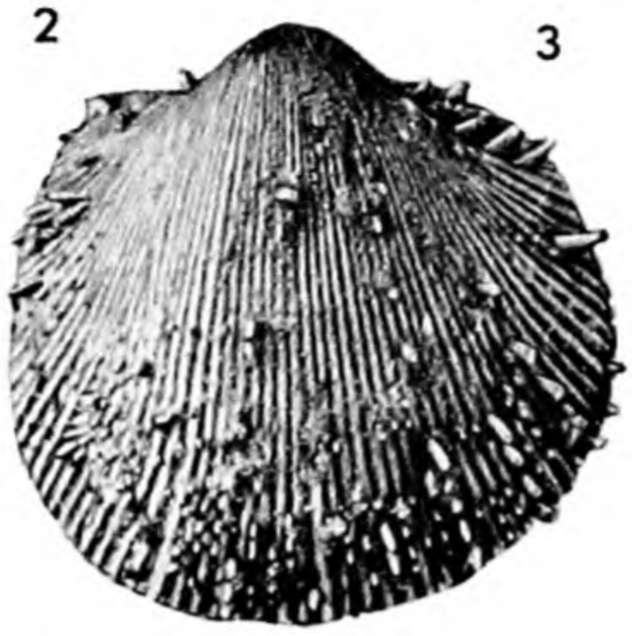

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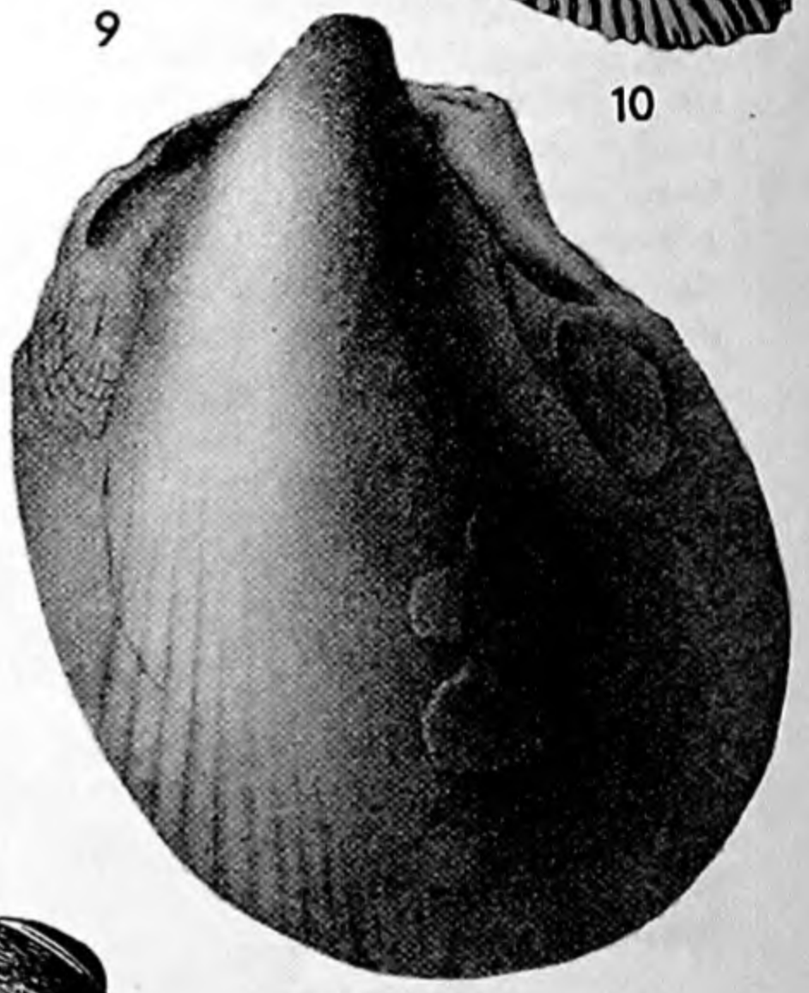

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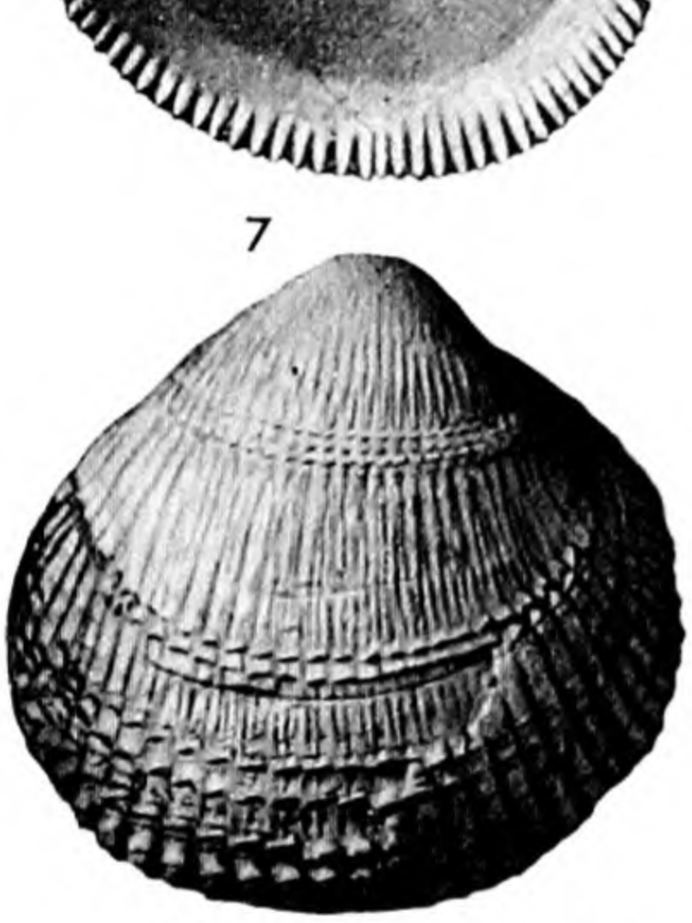

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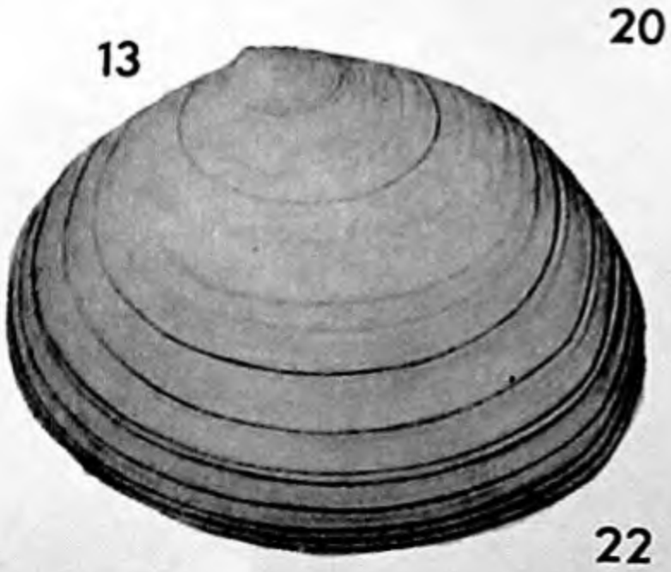

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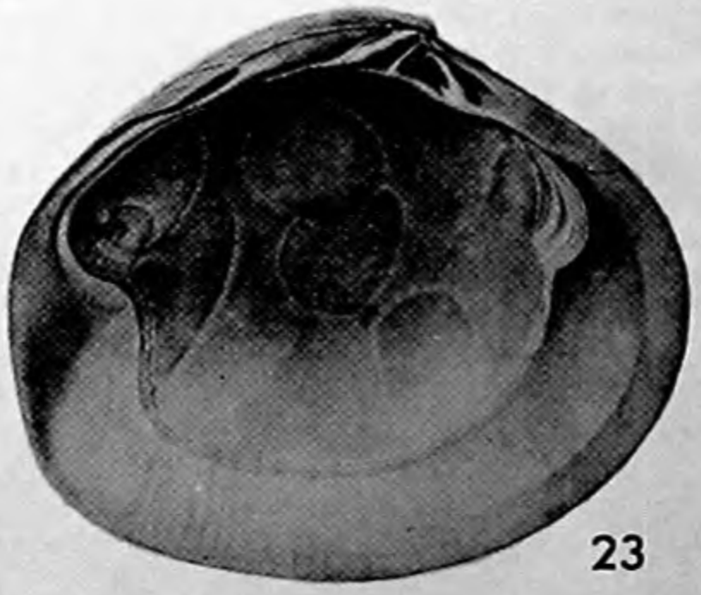

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shorter and usually obliquely truncate; somewhat gaping posteriorly; margins entire; surface smooth; one cardinal and one posterior lateral tooth in each valve; ligament external; pallial line simple. **Trias.–Cret.**

T. bulbosa Whitfield (**168**—21). Anterior portion marked with a broad, shallow depression. **U. Jura.** (Sundance): S. Dak., Wyo.

T. americana Meek and Hayden (**168**—20). **U. Cret.** (Montanan): Sask. and Alta. to N. Mex.

PARACYCLAS Hall 1843

(**P. elliptica*). Suborbicular, thin-shelled, with small and low beaks and short hinge line; posterior portion near beaks more or less defined by an oblique furrow, sometimes with posterior hinge extremity almost winged; surface concentrically striated, striae often ridgelike; lunule absent; ligament set in deep groove; pallial line simple. **Dev.**

P. (Ilionia) ohioensis (Meek) (**168**—13). **Dev.** (Onondaga–Hamilton): Ont.; N. Y., Ohio, Ind., Ky.

***P. elliptica** Hall (**168**—15). **Dev.** (Onondaga–Hamilton): Ont.; N. Y., Pa., Ohio., Mich., Wis.; **Oriskany:** Ala. (Jemison).

P. lirata (Conrad) (**168**—14). **Dev.** (Onondaga–Portage): Ont.; N. Y. to Md. to Ia., Ala.

LUCINA Bruguière 1797

(**Venus pensylvanica* Chemnitz). Shell thin, rounded, convex or lenticular, slightly inequilateral, equivalve; shell substance porcelaneous or chalky; lunule deep and narrow; hinge usually with two cardinal teeth and one to two lateral teeth in each valve; anterior adductor scar elongated and placed mostly within pallial line; pallial line entire; sculpture usually concentric only. **Trias.–Recent.**

L. subundata Hall and Meek (**168**—28). Small, rarely reaching 12 mm in height, and with fine and close concentric lines. **U. Cret.:** Coloradoan of Utah; Montanan of Great Plains and Rocky Mountain region.

L. occidentalis Morton (**168**—22, 23). **U. Cret.** (Montanan): Great Plains and Rocky Mountain region.

L. smithi Meyer (= **L. whitei** Clark) (**168**—24). **Eoc.:** Md. to La.

L. curta Conrad (= **L. uhleri** Clark) (**168**—26, 27). Like *L. smithi* in size and shape, but differs in having smooth margin and lacking posterior fold. **Eoc., Olig.** (Chickasaw–Vicksburg): Md. and Gulf Coastal Plain.

L. (Lucinoma) acutilineata Conrad (= **Phacoides acutilineatus**) (**168**—25). **Olig.:** Wash.; **Mioc.:** Alaska to Cal.; **Plioc.** and **Pleist.:** Cal.; **Recent:** Alaska to Mex.

TARAS Risso 1826

(= DIPLODONTA Bronn 1831)

(**Taras antiquatus*). Thin-shelled, orbicular, convex, concentrically striate or pustulose; cardinal teeth two in each valve, the left anterior and right posterior bifid, lateral obscure or lacking; adductor scars continuous peripherally with pallial line; no pallial sinus. **Tert.–Recent.**

T. hopkinsensis (Clark) (**168**—31, 32). **Eoc.** (Chickasaw): Atlantic and Gulf Coastal Plain.

T. acclinis (Conrad) (**168**—29, 30). **U. Olig.:** Fla.; characteristic of **Mioc.:** N. J. to Ga.; **Plioc.:** N. C., Fla.

T. parilis (Conrad) (**168**—33). **Mioc.:** Wash. to Cal.; **Plioc.:** Cal. (Jacalitos, Etchegoin).

TENEA Conrad 1870

(**T. parilis*). Subcircular, thin-shelled, tumid; left valve with V-shaped cardinal tooth, the anterior lobe of which is continued along anterior margin of shell and separated from it by a deep groove; right valve with two cardinal teeth, the anterior falcate, the posterior curved backwards; laterals lacking; valve margins smooth; pallial line with narrow and deep sinus. **Cret.**

***T. parilis** Conrad (**169**—1). Shell very fragile. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

Superfamily CARDIACEA

CARDIUM Linnaeus 1758

(**C. costatum*). Shell convex, umbos prominent, incurved, turned slightly forward; hinge line curved; surface radially ribbed or striated; valve margins crenulated; cardinal teeth one or two in each valve; lateral teeth short, distant from cardinals. **Trias.–Recent.**

C. pauperculum Meek (**169**—5). When plications are preserved, an angular appearance is given to the posterior umbonal slope by the greater elevation of three to four of the plications there. **U. Cret.** (Coloradoan): Wyo., Colo., N. Mex., Utah.

C. (Ethmocardium) whitei Dall (= **C. speciosum** Meek and Hayden) (**169**—6). On the inner surface of the shell are rows of small pits corresponding to the grooves between the ribs and which on the in-

PLATE 169

[Figures are x1 unless otherwise indicated.]

1. Tenea parilis [USGS, PP 137]. Left exterior (x2). **2–13. Cardium** spp. **2–4. C. tenuistriatum** [Pal N J 1]. Right valve, shell surface enlarged, and side view of a filling. **5. C. pauperculum** [USGS, B 106]. Right exterior (x2). **6. C. whitei** [USGS Ter 9]. Right valve of larger type specimen. **7, 8. C. dumosum** [USGS, PP 137]. Right interior and exterior. **9, 10. C. eufaulense** [Md G S, U Cret]. Left interior and exterior. **11. C. spillmani** [Pal N J 1]. Impression of right interior. **12, 13. C. coosense** [USGS, PP 59]. Right side and dorsal views of type. **14–16. Protocardia** spp. **14, 15. P. subquadrata** [USGS Ter 9]. Right side and posterior views. **16. P. texana** [USGS, B 205]. Right valve. **17. Cardium linteum** [USGS, B 398]. Right exterior (x2). **18, 19. Isocardia fraterna** [Md G S, Mioc]. Right exterior and left interior (x0.6). **20–24. Cyprimeria** spp. **20. C. texana** [U Tex B 2838]. Left valve (x0.5). **21, 22. C. depressa** [Md G S, U Cret]. Dorsal and exterior views of left valve. **23, 24. C. alta** [USGS, PP 137]. Left interior and exterior (x0.5).

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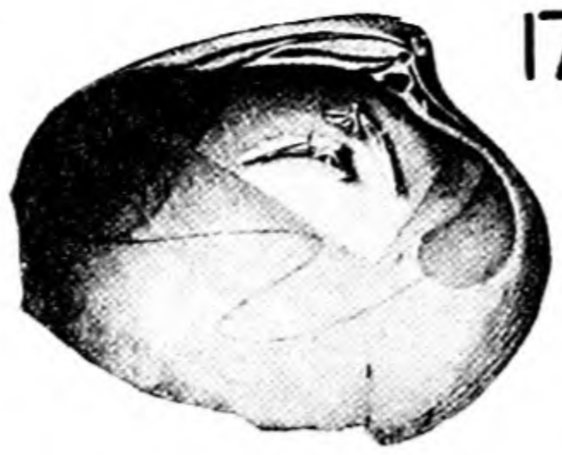

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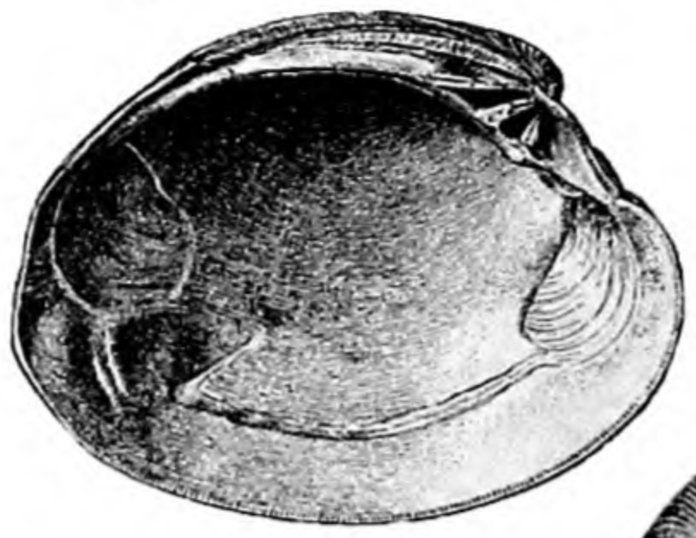

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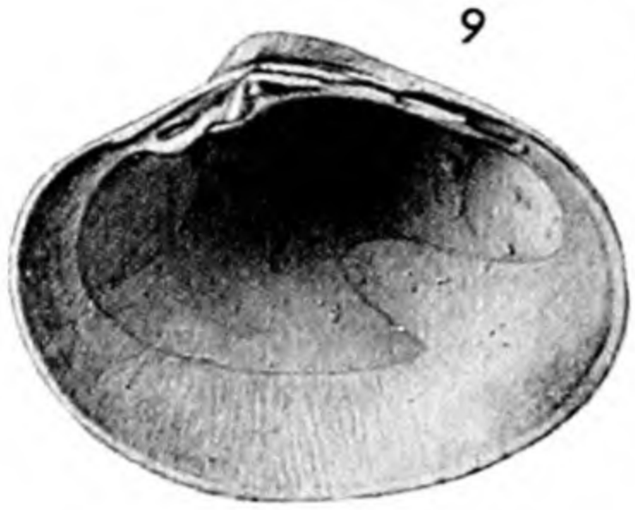

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ternal fillings form a series of small tubercles. **U. Cret.** (Montanan): N. and S. Dak., Mont., Colo., N. Mex.

C. (Granocardium) tenuistriatum (Whitfield) (**169**—2–4). Ribs wider than interspace; bear rows of narrowly compressed spines, each third row usually more conspicuous than the other two. **U. Cret.:** N. J. (Matawan).

C. (Granocardium) dumosum Conrad (**169**—7, 8). Differs from preceding in its broader radial interspaces (spaces and ribs of about same width), its lesser convexity, and its smaller size. **U. Cret.** (*Exogyra ponderosa* zone): N. J., Md. (Matawan), N. C. (Snow Hill), Ga., Ala. (Blufftown), Miss. (Coffee).

C. eufaulense Conrad (**169**—9, 10). Higher than wide; hinge arcuate; shell narrower than preceding with stronger angular costae (35 to 40). **U. Cret.:** Ga., Ala. (Ripley and Providence), Miss. (Ripley and Owl Creek).

C. spillmani Conrad (**169**—11). Radiating ribs on posterior portion only. **U. Cret.** (*Exogyra costata* zone): Atlantic and Gulf Coastal Plain to Miss.

C. linteum (Conrad) (= **C. cooperi** Gabb) (**169**—17). **Eoc.** (Martinez–Tejon): Wash. to Cal.

C. line (Conrad). Lacks concentric ridges of *Protocardia* **Eoc.:** Md. (Pamunkey), Va., Ala. (Wilcox).

C. coosense Dall (**169**—12, 13). **Mioc.:** Wash., Ore., Cal.; **Plioc.:** Wash., Cal. (probably a variety of *C. corbis* (Martyn), **Mioc.–Recent** of Wash. to Cal.).

PROTOCARDIA Beyrich 1845

(**Cardium hillanum* Sowerby). Similar to *Cardium*, but with radiating ribs only on posterior portion of shell, the remainder bearing concentric ridges; lunule and escutcheon lacking. **Jura., Cret.**

P. texana Conrad (**169**—16). **L. Cret.** (Washita): Colo., Tex. (Buda), N. Mex. (Purgatoire).

P. subquadrata Evans and Shumard (**169**—14, 15). Small; radial ribs of posterior portion somewhat obscure. **U. Cret.** (Montanan): Sask., Alta.; N. and S. Dak., Wyo.

Superfamily ISOCARDIACEA

ISOCARDIA Lamarck 1799

(**I. cor*). Inflated, smooth or concentrically striated; beaks distant, prominent and much produced and spirally enrolled toward front; each valve with two nearly parallel cardinal teeth and one posterior lateral. **Jura.–Recent.**

I. fraterna Say (**169**—18, 19). **Mioc.:** Md. to N. C.

Superfamily VENERACEA

CYPRIMERIA Conrad 1864

(**Cytherea excavata* Morton). Differs from *Venus* in having the margins of valves smooth; the first anterior left cardinal and anterior two right cardinals are entire, the rest grooved or bifid; pallial sinus very shallow. **Cret.**

C. texana (Roemer) (= **Arcopagia texana**) (**169**—20). Entire shell very thin, owing to slight convexity of valves; valves slightly unequal, with a somewhat twisted appearance. Common in **L. Cret.:** Fredericksburg of Tex.

C. crassa Meek. Differs from *C. texana* in being larger and thicker; 67 mm high, 78 mm long, 23 mm deep. **L. Cret.:** Fredericksburg–Eagle Ford of Tex.; Fredericksburg and Washita of N. Mex.

C. depressa Conrad (**169**—21, 22). **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

C. alta Conrad (**169**—23, 24). **U. Cret.** (upper part of *Exogyra costata* zone): Md. to Tex.

CLEMENTIA Gray 1842

(**Venus papyracea* Gray). Inequilateral, thin-shelled, inflated; beaks prominent; valve margins entire; surface concentrically sculptured; anterior left and two posterior right hinge teeth bifid; lateral teeth lacking; pallial sinus long and angular, narrow and ascending. **Eoc.–Recent.**

C. (*Egesta) inoceriformis (Wagner) [Type of subgenus EGESTA Conrad 1845], (**170**—1, 2). **Mioc.:** N. J. (Shiloh), Md. (Calvert–St. Marys).

C. (Egesta) pertenuis (Gabb) (**170**—3). Sculpture of coarse concentric waves and fine concentric threads. **Mioc.,? L. Plioc.:** Cal.

VENUS Linnaeus 1758

(**V. verrucosa*). Valves equal, inequilateral, of a rounded subtrigonal outline, thick, concentrically or faintly radially sculptured; margins crenulate; hinge plate broad, with three cardinal teeth in each valve (the middle left and posterior two right being bifid), and no lateral teeth; pallial sinus short,

PLATE 170

[Figures are x1 unless otherwise indicated.]

1–3. Clementia spp. **1, 2. C. (Egesta) inoceriformis** [USGS, PP 147]. Exterior and interior of left valve, the holotype (x0.5). The hinges glued on the interior are labeled "Shiloh, N. J." **3. C. (Egesta) pertenuis** [USGS, B 398]. Right exterior (x0.5). **4–7. Trigonocallista** spp. [USGS Ter 9]. **4, 5. T. nebrascensis.** Left exterior; anterior profile of united valves. **6, 7. T. deweyi.** Left side and dorsal views. **8–10. Venus** spp. **8, 9. V. (Mercenaria) mercenaria** (x0.5) [Md G S, Mioc]. Right exterior and left interior. **10. V. (Chione) securis** [San Diego Soc N H, Mem 1]. Left exterior (x0.6). **11, 12. Meretrix eufaulensis** [USGS, PP 137]. Right exterior and interior (x4). **13–16. Dosiniopsis** spp. **13–15. D. lenticularis** [Md G S, Eoc]. Right exterior and interior, and dorsal view. **16. D. stewartvillensis** [U Cal Pub, Dp G 17]. The type, a left valve. **17–19. Meretrix** spp [USGS, PP 137]. **17, 18. M. (Aphrodina) tippana.** Right interior and left exterior. **19. M. cretacea.** Right exterior (x2). **20, 21. Pitar** spp. [Ac N Sc Phila, J 3]. **20. P. (Macrocallista) horni. 21. P. uvasana.** Right exterior. **22–27. Tellina** spp. **22. T. equilateralis** [USGS Ter 9]. Left side of an imperfect specimen. **23. T. soledadensis** (x1.75) [GSA, SP 10]. **24, 25. T. williamsi** [Md G S, Eoc]. Left exterior and interior (x2). **26. T.? undulifera** [U Cal Pub, Dp G 15]. Left exterior. **27. T. declivis** [Md G S, Mioc]. Left value (x2.5).

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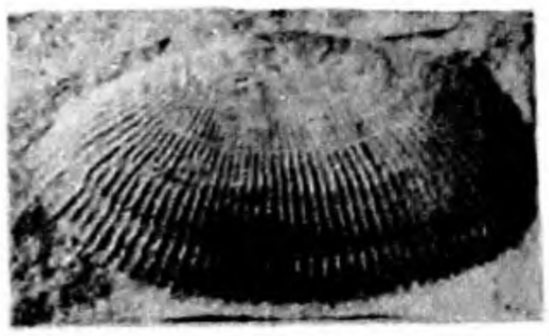

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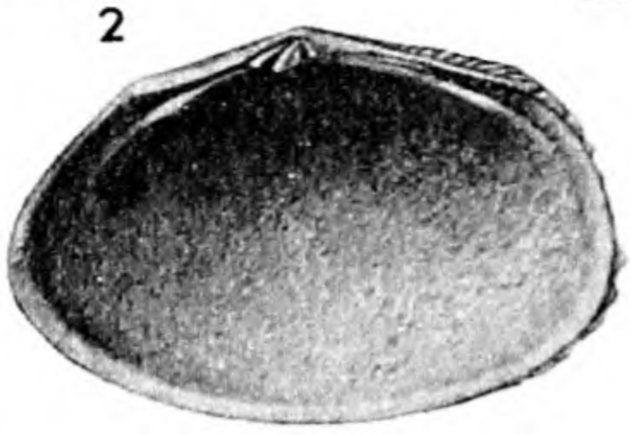

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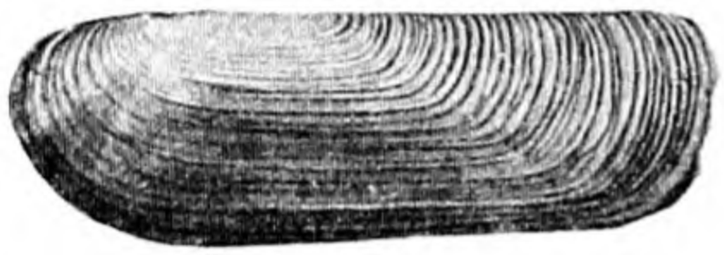

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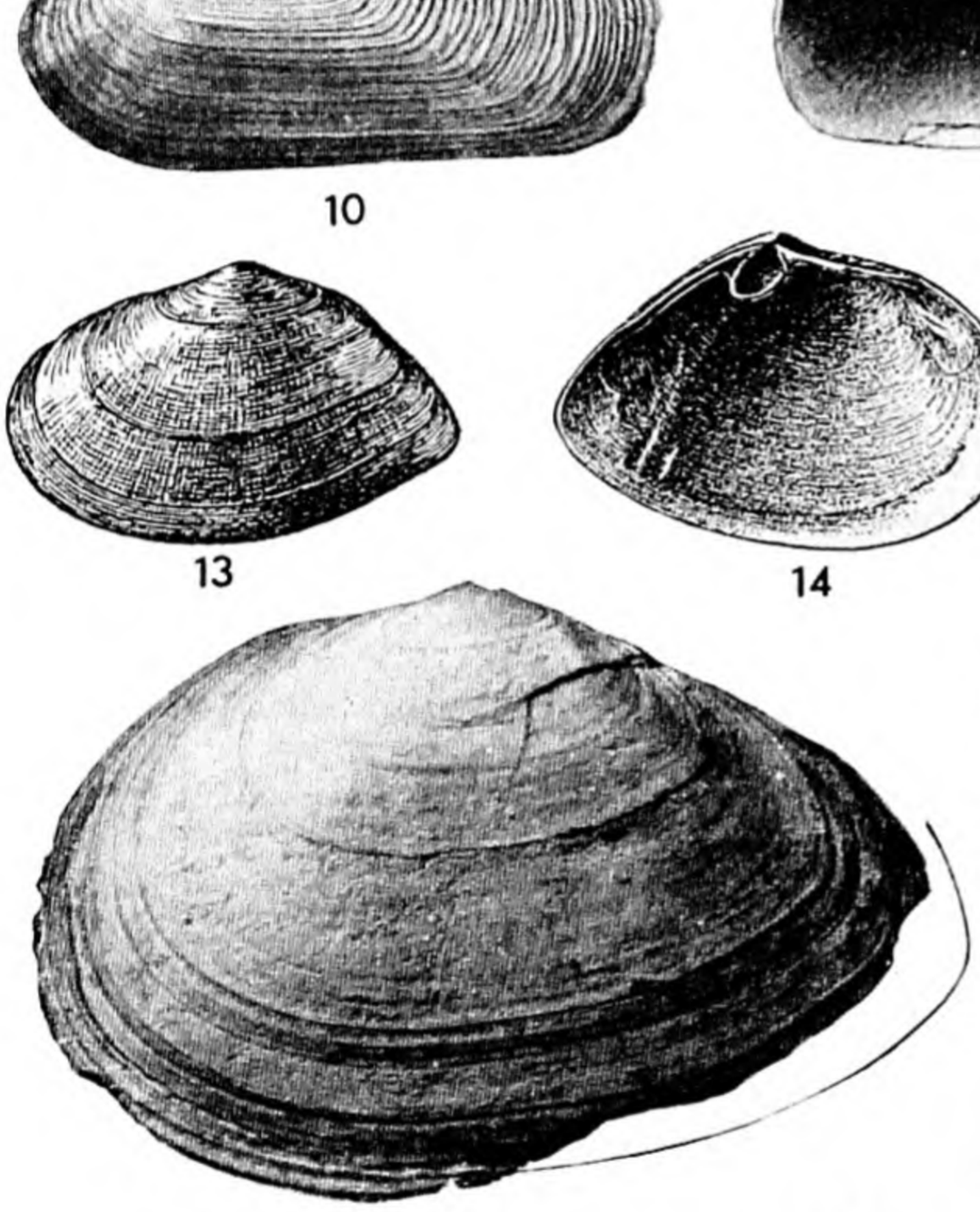

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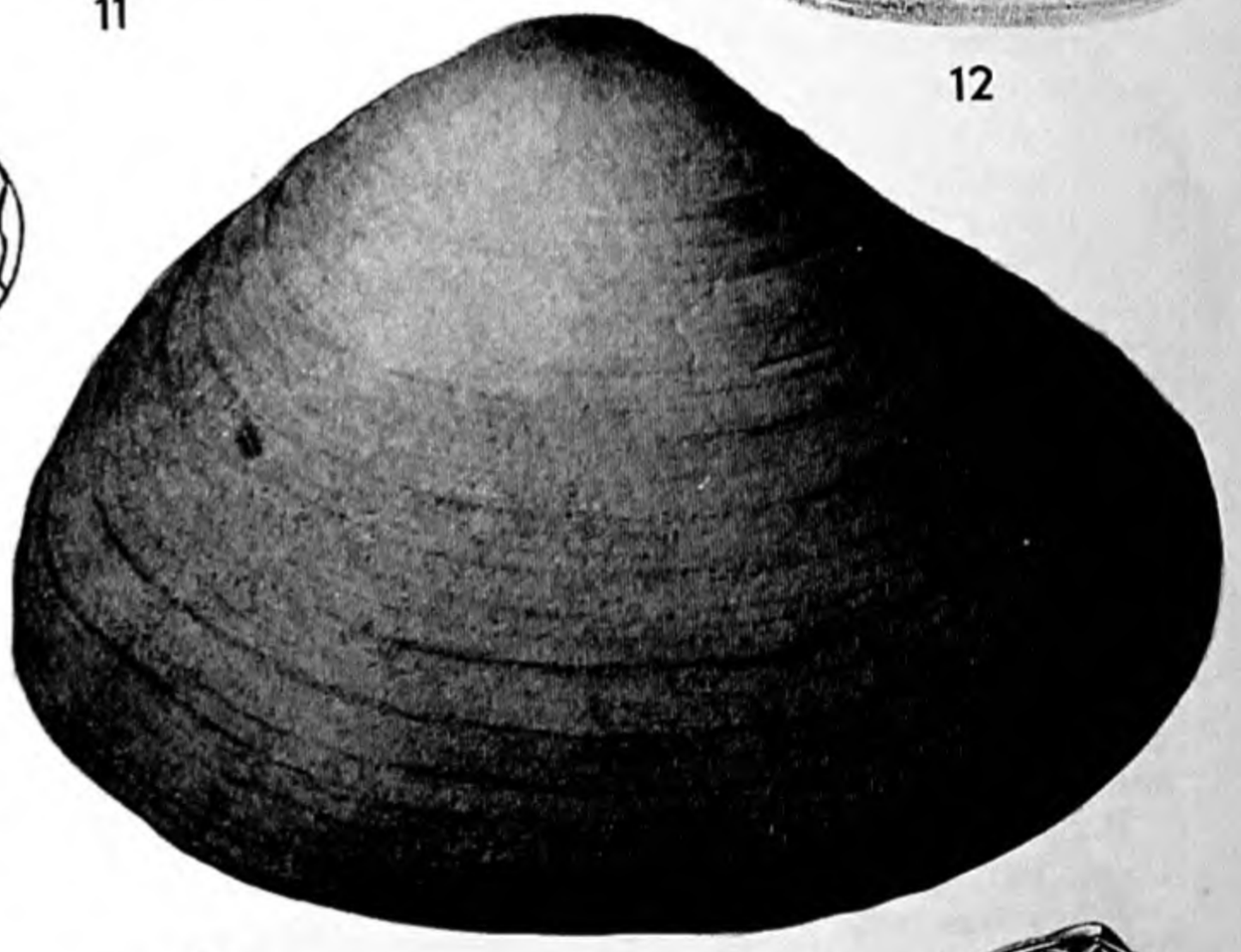

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angular; the two adductor scars marginal. **Jura.–Recent.**

Among the subgenera, MERCENARIA Schumacher 1817 has fine growth lines but no radial sculpture, although the margins are crenulated internally and the radial sculpture appears with the slightest wear. CHIONE Muhlfeldt 1811 is trigonal, has distant concentric lamellae appearing as erect frills, and also fine radial plications.

V. (*Mercenaria) mercenaria Linnaeus (**170**—8, 9; **173**—10, 11). **Mioc.–Recent:** Atlantic Coastal Plain.

V. (Chione) securis Shumard (**170**—10; **172**—19). **Mioc.:** Wash., Ore., Cal.; **Plioc.:** Cal.

V. (Chione) latilirata Conrad (**173**—7–9). **Mioc.:** Md. (Choptank, Calvert).

MERETRIX Lamarck 1799

(**Venus meretrix* Linnaeus). Thick, trigonal, smooth, or concentrically striated; lunule well marked; margin entire; ligament external; hinge thick, with three cardinal teeth in each valve, an anterior lateral in left valve and a corresponding socket bordered by laminae in right; no posterior lateral present; middle left and anterior two right cardinals are entire and smooth, the others grooved and bifid; differs from *Venus* in possessing lateral teeth and in lacking fine crenulations of valve margin. **Jura.–Recent.**

M. eufaulensis (Conrad) (**170**—11, 12). **U. Cret.** (Ripley and equivalents): N. J., Tenn., Ala.

M. (*Aphrodina) tippana Conrad (**170**—17, 18). Type of subgenus. **U. Cret.:** Md. (Monmouth), Tenn., Ga. to Miss. (Ripley), Tex. (Nacatoch).

M. cretacea (Conrad) (**170**—19). **U. Cret.:** N. J. and Del. (Matawan), Tenn. (Ripley).

DOSINIOPSIS Conrad 1864

(**D. meeki*). Very similar to *Meretrix*, but pallial sinus is acutely angular and ascending; also, besides anterior lateral teeth there is a single distinct posterior lateral in the right valve with a corresponding socket in the left; posterior cardinal of right valve broad and deeply channeled above. **Eoc.**

***D. lenticularis** (Rogers) (= **D. meeki** Conrad) (**170**—13–15). **Eoc.:** Md. (Aquia).

D. stewartvillensis Clark and Woodford (**170**—16). **Eoc.:** Cal. (Meganos).

TRIGONOCALLISTA Rennie 1930

(**Meretrix umzambiensis* Woods). The Cretaceous forms of *Dosiniopsis*; they are more trigonal in outline and have smooth laterals, the posterior cardinal tooth is narrower and the pallial sinus more ascending. **Cret.**

T. deweyi (Meek and Hayden) (**170**—6, 7). **U. Cret.** (Montanan): Sask. and Alta. to N. Mex. Ranging upward into Lance in N. and S. Dak., N. Mex.

T. nebrascensis (Meek and Hayden) (**170**—4, 5). Lunule and escutcheon prominent. **U. Cret.:** Fox Hills of Great Plains and Rocky Mountain region, ranging up into Lance. Occurs rarely in Pierre.

PITAR Roemer 1857

(**Venus tumens* Gmelin). Differs from *Meretrix* mainly in its cardinal teeth; left valve has a large posterior cardinal and a thinner cardinal in front; right valve has a strong posterior cardinal and two other cardinals close together, the anterior very thin; in both valves there is a long posterior ridge; pallial sinus pointed, reaching to the middle of the valve. **Eoc.–Recent.**

P. uvasana (Conrad) (**170**—21). **Eoc.** (Tejon): Wash. to Cal.

P. (Macrocallista) horni (Gabb) (**170**—20). **Eoc.** (Tejon): Wash. to Cal.

DOSINIA Scopoli 1777

(**Chama dosin* Adanson = *Dosinia africana* Hanley). Shell of circular outline and low convexity; surface with distant concentric grooves; lunule impressed, escutcheon linear or obsolete; hinge plate broad, with flat platformlike area in each valve behind teeth; pallial sinus distinct, V-shaped, generally strongly ascending; valve margins smooth. **Eoc.–Recent** (N. America); **Mioc.–Recent** (Europe); **Cret.?, Eoc.–Recent** (New Zealand).

D. mathewsonii Gabb (**173**—1). **L.** and **M. Mioc.:** Cal. (Vaqueros).

Superfamily TELLINACEA

TELLINA Linnaeus 1758

(**T. radiata*). Oval, transversely elongate, slightly inequivalve, compressed, rounded anteriorly, angular and gaping posteriorly; surface marked by oblique fold extending from umbo to lower posterior border; beaks more or less twisted; valve margins smooth; two cardinal teeth present in each valve, and one anterior and one posterior lateral; laterals often indistinct in left valve; ligament external, prominent; pallial sinus wide and deep. **Jura.–Recent** (worldwide distribution).

PLATE 171

[Figures are x1 unless otherwise indicated.]

1, 2. Aenona eufaulensis [USGS, PP 137]. Right valve (x2). **3–5. Linearia** spp. **3, 4. L. metastriata** [USGS, PP 137]. Left valve (x4). **5. L. multicostata** [Ac N Sc Phila, SP 3]. Plaster "cast" of holotype. **6, 7. Tellinimera eborea** [Md G S, U Cret]. Dorsal view and right exterior (x2). **8, 9. Semele** spp. **8. S. rubropicta** [USGS, B 398]. Right valve. **9. S. subovata** [Md G S, Mioc]. Right exterior (x2). **10, 11. Leptosolen biplicata** [USGS, PP 137]. Views of left valves. **12. Legumen ellipticum** [Ac N Sc Phila, J (2) 3]. Right valve of type. **13, 14. Cumingia medialis** [Md G S, Mioc]. Exterior and interior of left valves (x1.5). **15. Macoma nasuta** [USGS, B 398]. Imperfect left valve. **16–18. Mactra** spp. **16. M. (Spisula) albaria** [USGS, PP 59]. Right valve of large specimen. **17, 18. M. clathrodon** [Md G S, Mioc]. Views of a left valve. **19–27. Cymbophora** spp. **19, 20. C. alta** [USGS Ter 9]. Right exterior of type and hinge of right valve (x0.6). **21, 22. warrenana** [USGS Ter 9]. Left exterior and anterior views of type. **23. C. lintea** [Pal N J 1]. Left valve (x2). **24, 25. C. emmonsi** [USGS, B 106]. Two views of left valve. **26, 27. C. ashburneri.** Right valve [Ac N Sc Phila, SP 3]; left hinge (x1.5) [JP 11].

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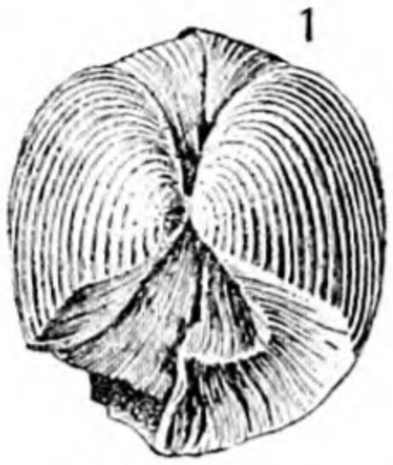

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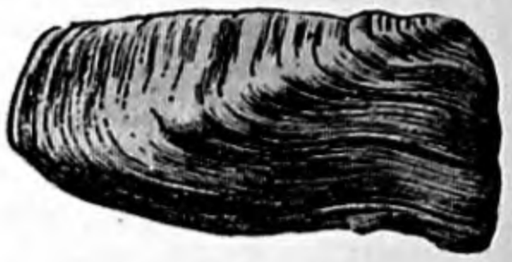

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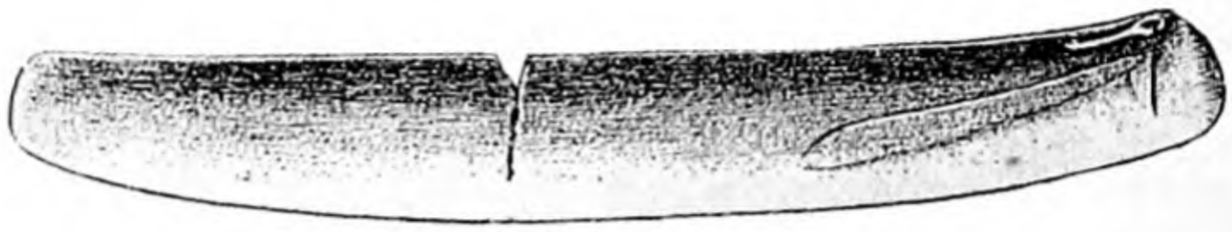

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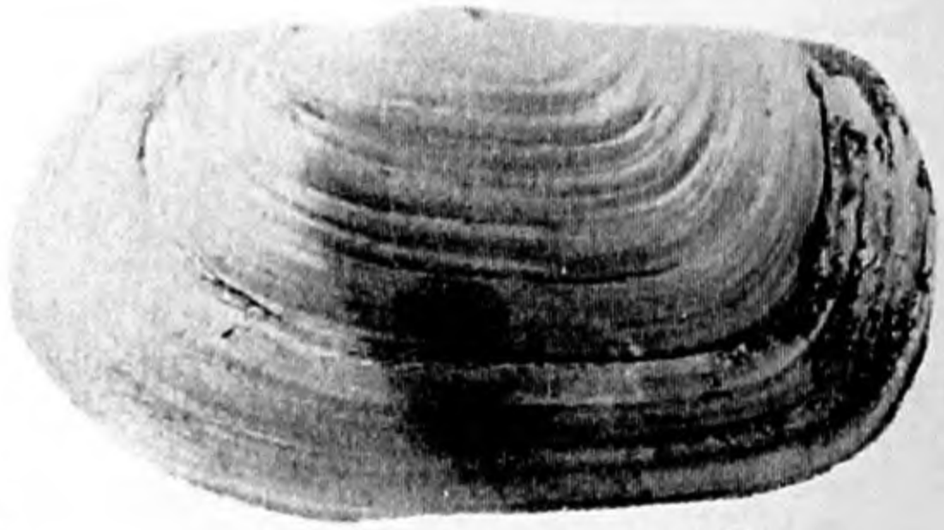

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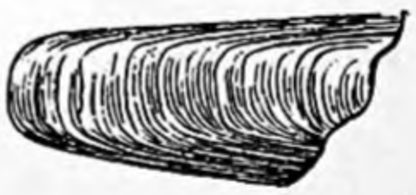

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T. equilateralis Meek and Hayden (**170**—22). Posterior end slightly truncate. **U. Cret.** (Montanan); Sask. and Alta. to N. Mex.

T. soledadensis Hanna (**170**—23). **Eoc.:** Ore. (U. Umpqua), Cal.

T. williamsi Clark (**170**—24, 25). Lateral teeth strongly developed. **Eoc.** (Aquia, Nanjemoy): Md., Va.

T. declivis Conrad (**170**—27). **Mioc.:** N. J. to Va.; **Plioc.** and **Pleist.:** Fla.

T. undulifera Gabb (**170**—26). **Paleoc.** (Martinez): Cal.

LINEARIA Conrad 1860

(**L. metastriata*). Differs from *Tellina* in lengthening of bifid cardinal teeth, rounding of shell posteriorly and anteriorly, and in having surface partly or wholly radially ribbed; umbonal ridge obsolete. **U. Cret.**

***L. metastriata** Conrad (**171**—3, 4). **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Costal Plain.

L. multicostata (Gabb) (**171**—5). **U. Cret.** (Chico): Ore.

TELLINIMERA Conrad 1860

(**T. eborea*). In left valve, anterior cardinal tooth is V-shaped, nearly direct or slightly pointing anteriorly; posterior cardinal bifid, oblique; cardinal plate channeled posteriorly and bearing anteriorly a small pit. **Cret.**

***T. eborea** Conrad (**171**—6, 7). **U. Cret.:** N. J. (Matawan), Md. (Monmouth), Gulf Coastal Plain (Ripley).

AENONA Conrad 1870

(**Tellina eufaulensis*). Subtriangular, inequilateral; beaks very small, pointed; lunule lanceolate, marked by a deeply impressed line; two small, widely divergent cardinal teeth in right valve, one bifid and one rudimentary one in left; dorsal margins beveled to function as laterals, but no true laterals developed. **Cret.**

***A. eufaulensis** Conrad (**171**—1, 2). Differs from *Tellinimera eborea* in its more nearly equilateral outline and in lacking the sharp concentric striations. **U. Cret.:** Matawan of N. J.; Monmouth of Md.; Ripley, Owl Creek, and Providence of Gulf Coastal Plain.

MACOMA Leach 1819

(**M. tenera*). Shell smooth; less elongated than *Tellina*; hinge without laterals. **Mioc.–Recent.**

M. nasuta (Conrad) (**171**—15). Shell thin; within each valve, a rounded ridge descends from beaks toward lower posterior angle. **Mioc.:** Alaska to Cal.; **Plioc.:** Cal.; **Pleist.:** Cal.; Mex.; **Recent:** Alaska to Mex.

SEMELE Schumacher 1817

(**Tellina reticulata* Spengler). Large, rounded, thick; posterior side slightly folded; both cardinal and lateral teeth present; pallial sinus large and rounded; resilifer elongate; external ligament feeble. **Eoc.–Recent.** Today in tropical and warm temperate seas.

S. subovata (Say) (**171**—9). **Mioc.:** Md., Va., Tex.

S. rubropicta Dall (**171**—8). **Plioc.:** Cal.; **Pleist.:** Cal. to Mex.; **Recent:** Alaska to Mex.

CUMINGIA Sowerby 1833

(**C. lamellosa*). Small, thin, oval, rounded anteriorly, somewhat wedge-shaped posteriorly; one small cardinal tooth in each valve; right valve with two strong lateral teeth, left with extended dorsal margins to fit in channels above laterals of right valve; these dorsal extensions form a lunule and escutcheon which are thus confined in the left valve; surface radially striated; concentric lines fine or lamellose; resilifer spoon-shaped; pallial sinus deep and wide; habit nesting, i.e., though not excavating burrows they occupy those made by true borers. **Eoc.–Recent.**

C. medialis Conrad (**171**—13, 14). **Mioc.:** Md. (Choptank), Va., N. and S. C.

Superfamily SOLENACEA

LEPTOSOLEN Conrad 1865

(**L. biplicata*). Thin, beaks anterior; epidermis unpolished; a strong internal rib directed vertically extends from beak to basal margin; pallial sinus very shallow; hinge with a single cardinal tooth in each valve. **Cret.**

***L. biplicata** Conrad (**171**—10, 11). Anterior extremity compressed, marked with two obscure plications extending obliquely forward and downward from beak. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain to Tex.

LEGUMEN Conrad 1858

(**L. ellipticum*). Equivalve, very inequilateral; hinge with two slender prominent teeth in right valve under beak, and one posterior, oblique, lamelliform lateral tooth. **Cret.**

PLATE 172

[Figures are x1 unless otherwise indicated.]

1–14. Corbula spp. 1, 2. C. pyriformis [USGS, B 128]. Right exterior and cardinal views. **3–5. C. subtrigonalis** [USGGS Ter 1878 (Hayden)]. Left valves and a dorsal view. **6, 7. C. crassiplicata** (x5) [Md G S, U Cret]. Double valves from left side, and right exterior. **8, 9. C. bisulcata** [NCGS 5]. Views of right valve (x3). **10, 11. C. oniscus** [Md G S, Eoc]. Cardinal view and right exterior (x4). **12. C. subcompressa** [B Am Pal 4]. Left valve (x2.5). **13, 14. C. aldrichi** [Md G S, Eoc]. Left and right valves (x4, x3). **15, 16. Saxicava arctica** (x2) [Md G S, Mioc]. Right exterior and left interior. **17, 18. Ensis ensiformis** [Md G S, Mioc]. Interior of left valve; posterior portion of broken valve. **19 Venus (Chione) securis** [USGS, B 398]. Left exterior. **20–22. Panope spp. 20. P. (Panope) generosa** [San Diego Soc N H, Mem 1]. Left valve (x0.7). **21, 22. P. decisa** [USGS, PP 137]. Right side and dorsal views.

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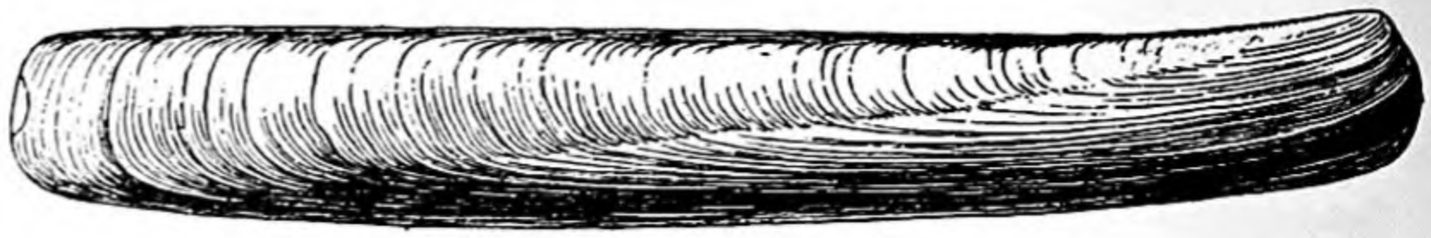

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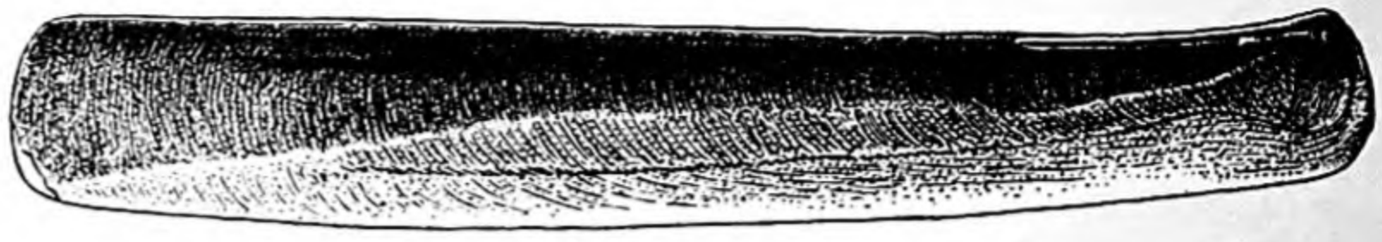

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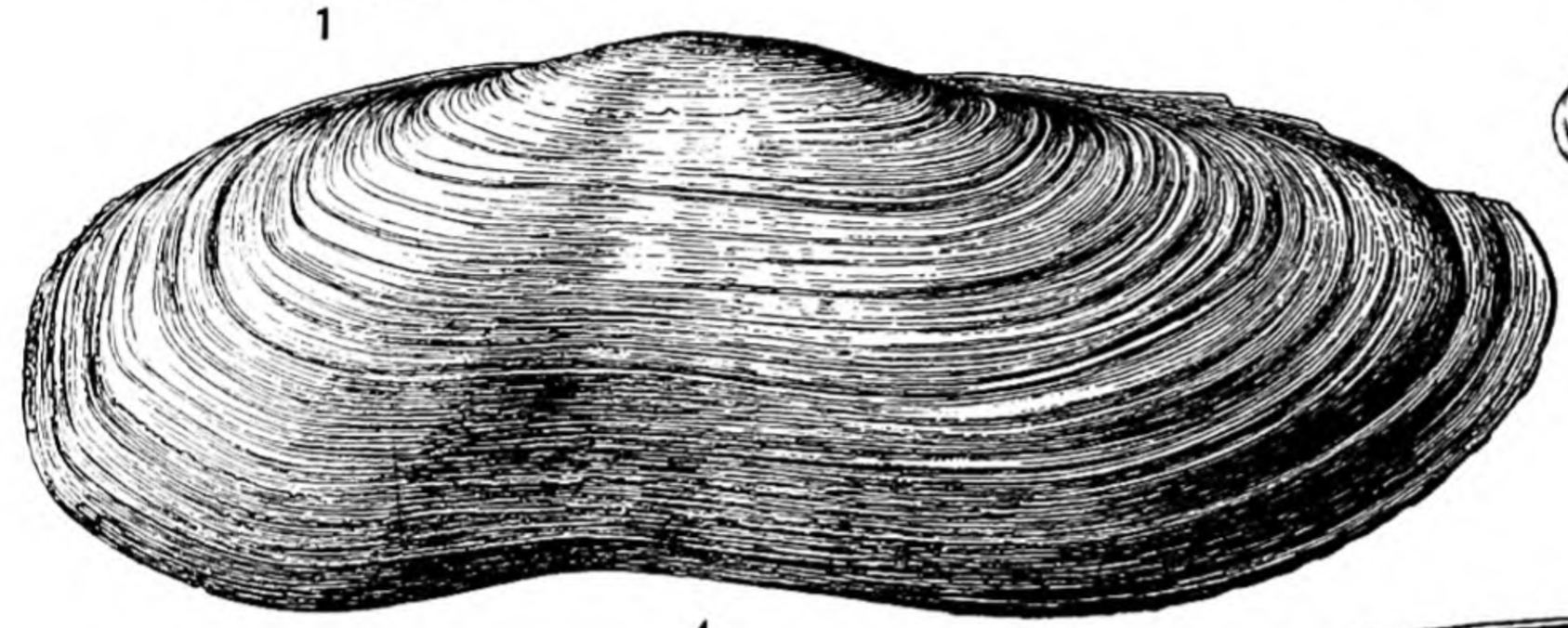

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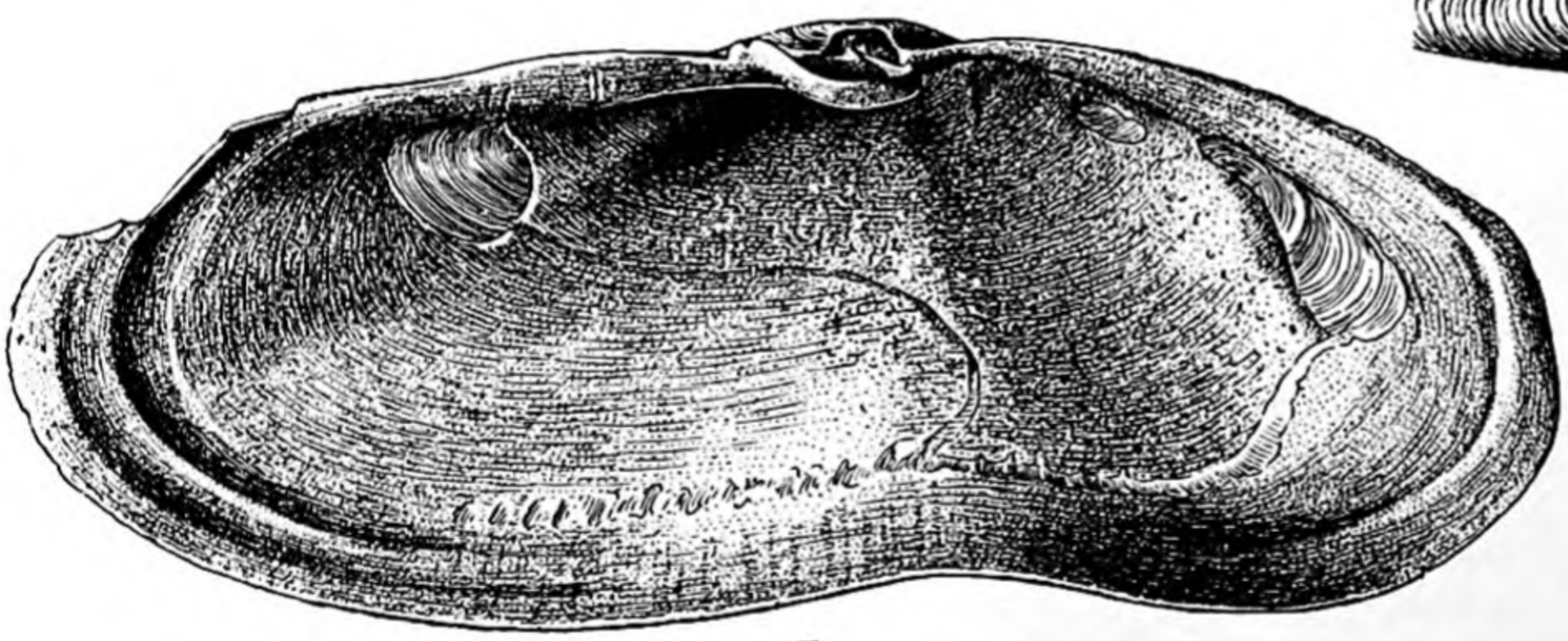

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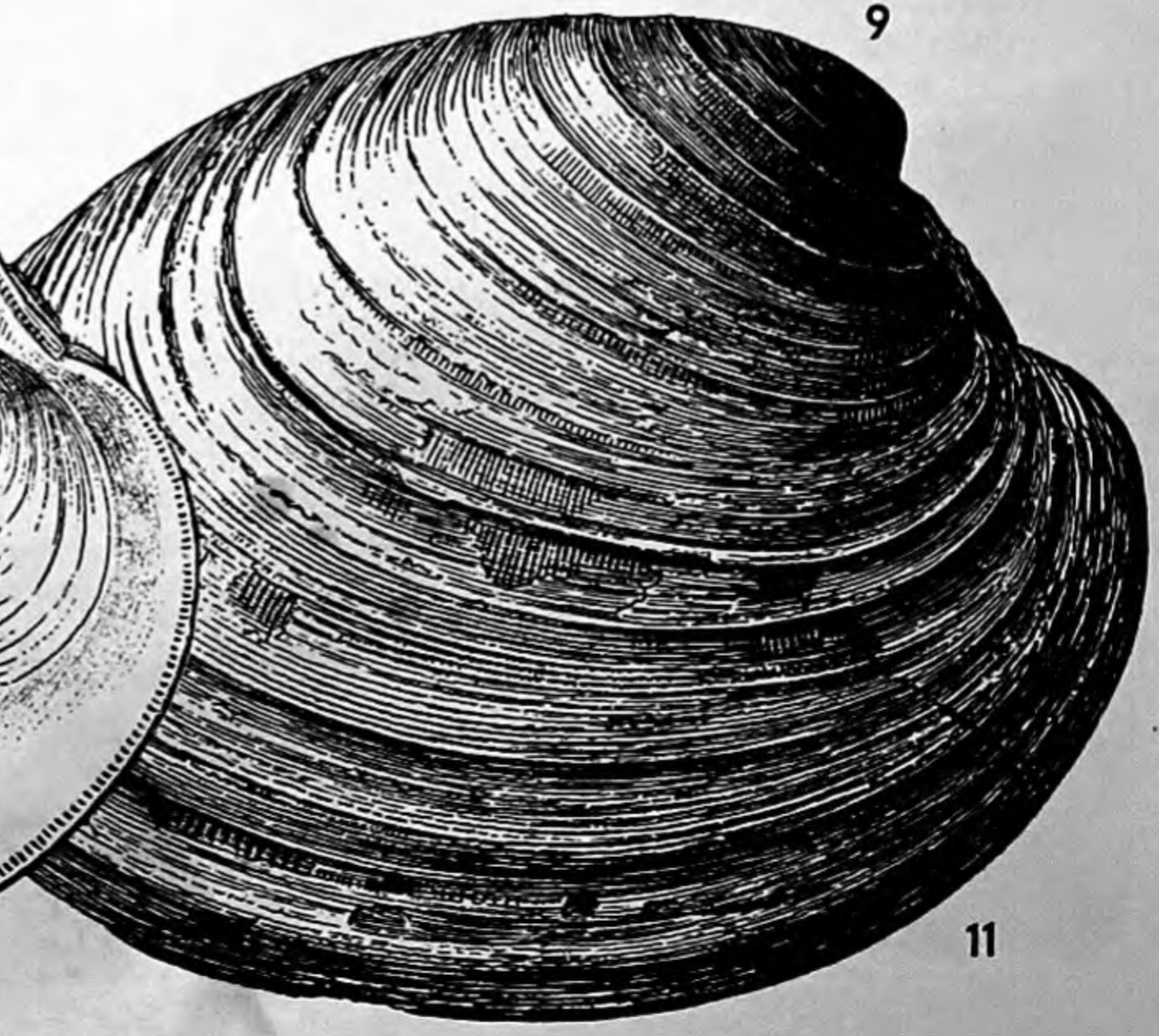

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***L. ellipticum** Conrad (**171**—12). **U. Cret.** (*Exogyra costata* zone): Md. (Monmouth), Tenn. (Coon Creek), Ga. and Ala. (Ripley), Miss. (Ripley and Owl Creek), Tex. (Navarro).

ENSIS Schumacher 1817

(**E. magnus*). Scabbard-shaped, straight, with terminal beaks. **Tert.–Recent.**

E. directus (Conrad) (**173**—2, 3). **Mioc.:** Md. (St. Marys).

E. ensiformis Conrad (**172**—17, 18). **Mioc.:** Md. (St. Marys, Choptank, Calvert).

Superfamily MACTRACEA

MACTRA Linnaeus 1767

(**Cardium stultorum*). Nearly equilateral, rounded triangular; surface smooth or concentrically sculptured; margins smooth; valves equal; lateral teeth elongate; hinge plate well developed; resilifer subtriangular, excavated out of hinge plate and separated from the scar of the external ligament by a thin raised plate, just posterior to beak at shell margin (in SPISULA Gray 1837 these are separated). **U. Cret.–Recent.**

M. clathrodon Lea (**171**—17, 18). Shell thin; lateral teeth crossed by equidistant, minute striae. **Mioc.:** Md. (St. Marys, Calvert).

M. (Spisula) albaria Conrad (**171**—16). **Olig.:** Vancouver Island, B. C.; Wash., Ore.; **Mioc.:** Alaska; Wash., Ore., Cal.; **Plioc.:** Cal.

CYMBOPHORA Gabb 1868

(= MACTRA in part of authors)

(**Mactra ashburneri*). Differs from *Spisula* in having margins of pit holding ligament and resilium elevated above hinge line. **Cret.** (distribution worldwide).

***C. ashburneri** (Gabb) (**171**—26, 27). **U. Cret.** (Chico): Vancouver Island, B. C.; Wash., Cal.

C. alta Meek and Hayden (**171**—19, 20). Lunule and escutcheon lance-oval. **U. Cret.** (Montanan): Alta to N. Mex.

C. lintea (Conrad) (**171**—23). **U. Cret.** (Matawan-Monmouth and equivalents): Atlantic and Gulf Coastal Plain.

C. emmonsi (Meek) (**171**—24, 25). **U. Cret.** (Coloradoan): Kan., Colo., Mont., Utah.

C. warrenana Meek and Hayden (**171**—21, 22). **U. Cret.** (Montanan): Sask. and Alta. to N. Mex.

Superfamily MYACEA

MYA Linnaeus 1758

(**M. truncata*). Valves unequal, more or less elongate, rounded in front and gaping behind; smooth externally; adductor scars subequal; pallial line sinuated; shell margins plain; area obsolete or lacking; ligament and resilium internal, opisthodetic, attached in left valve to a projecting chondrophore merging into dorsal margin behind, and in right valve to an inconspicuous chondrophore; hinge edentulous **Tert.–Recent.**

M. producta Conrad (**173**—4–6). **Mioc.:** Md. (Choptank).

CORBULA Bruguiere 1797

(**C. nucleus* Lamarck). Shell ovate, very inequivalve, close, rounded in front, contracted behind; umbos prominent; right valve convex, the larger, with a strong cardinal tooth in front of resilifer and with one posterior cardinal tooth; pallial line slightly sinuous posteriorly; marine to fresh-water. **Trias.–Recent.**

C. pyriformis Meek (**172**—1, 2). In fresh and brackish waters. **U. Cret.** (Bear River): Wyo., Idaho, Utah, and perhaps corresponding beds of Alta.

C. subtrigonalis Meek and Hayden (**172**—3–5). In marine, estuarine, and fresh waters; several varieties have been named. **U. Cret.** (Coloradoan–Lance): Sask. and Alta. to Colo.

C. bisulcata Conrad (**172**—8, 9). **U. Cret.:** N. J. and Md. (Matawan), N. C. (Black Creek).

C. crassiplicata Gabb (**172**—6, 7). **U. Cret.:** Eutaw–Ripley and equivalents of Atlantic and Gulf Coastal Plain to Tex.

C. subcompressa Gabb (**172**—12). **Paleoc.** (Midway): Tenn., Ala., Ark.

C. aldrichi Meyer (**172**—13, 14). **Paleoc., Eoc.:** Md. (Nanjemoy, Aquia), Ala., Tex. (Midway).

C. oniscus Conrad (**172**—10, 11). **Eoc.:** Md. (Nanjemoy, Aquia), Va., Gulf Coastal Plain.

SAXICAVA Fleuriau 1802

(**Mytilus rugosus* Linnaeus). Small, equivalve, oblong, elongate, gaping and hence not fully covering animal; umbos anterior; ligament external; the young with a cardinal tooth, but adult with teeth obsolete; surface rugose; pallial line sinuate, discontinuous; bores into soft rock. **Tert.–Recent.**

S. arctica (Linnaeus) (**172**—15, 16). **Mioc.:** N. J. to N. C.; Alaska; **Plioc.:** Fla.; Alaska; **Pleist.:** Ont. to Mass., *etc.*; Alaska to Mex.; **Recent:** Greenland to the West Indies, Alaska to Panama. (**S. rugosa** (Linnaeus), **Plioc.–Recent**, is less quadrangular, more elongate, with umbos less anterior than *S. arctica.*)

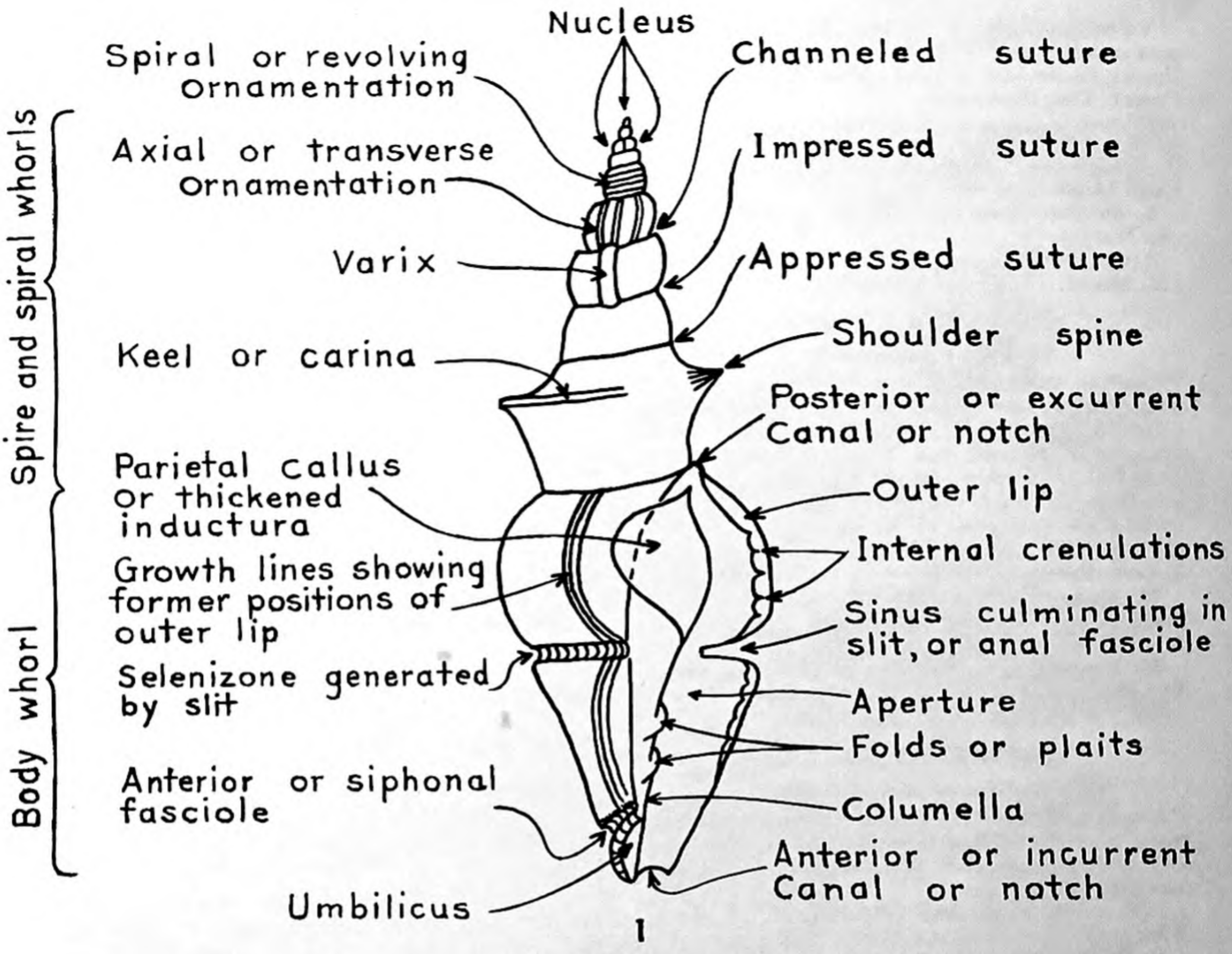
PANOPE Ménard 1807

(**P. aldrovandi*). Large, thick, equivalve, inequilateral, oblong, gaping widely behind and slightly in front, thus not fully covering soft parts of animal;

PLATE 173

[Figures are x1 and after Glenn [Md G S, Mioc] unless otherwise indicated.]

1. Dosinia mathewsonii [USGS, B 398]. Right valve. **2, 3. Ensis directus.** Right exterior and left interior. **4–6. Mya producta.** Left exterior and interior, and profile of hinge area of same valve. **7–11. Venus spp. 7–9. V. (Chione) latilirata.** Right exterior (x1.2) and interior (x1.6); dorsal view of a complete shell (after Dall). **10, 11. V. (Mercenaria) mercenaria.** Left interior and right exterior.



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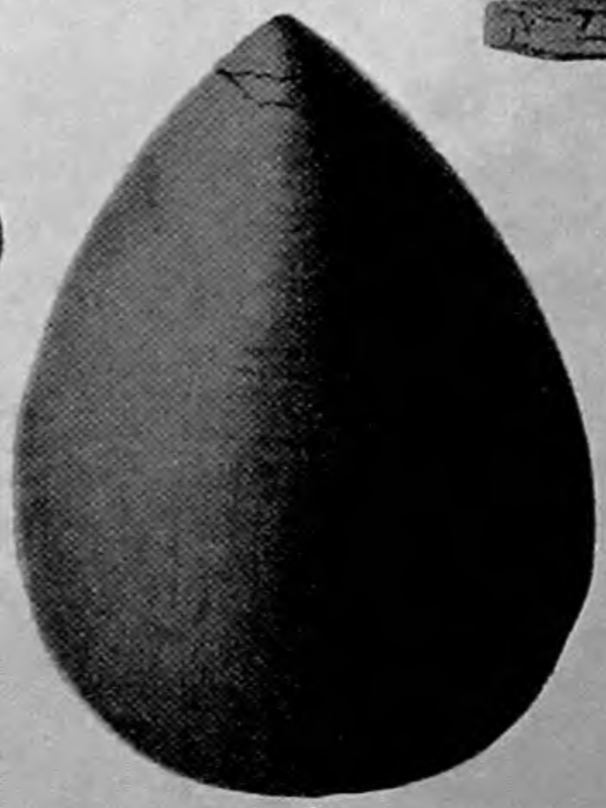

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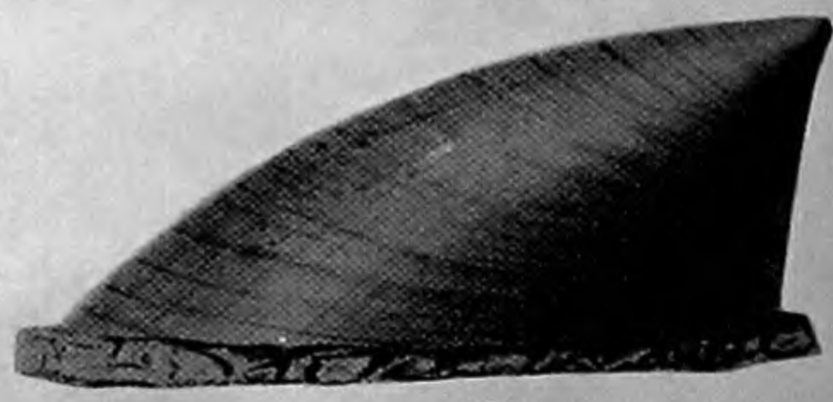

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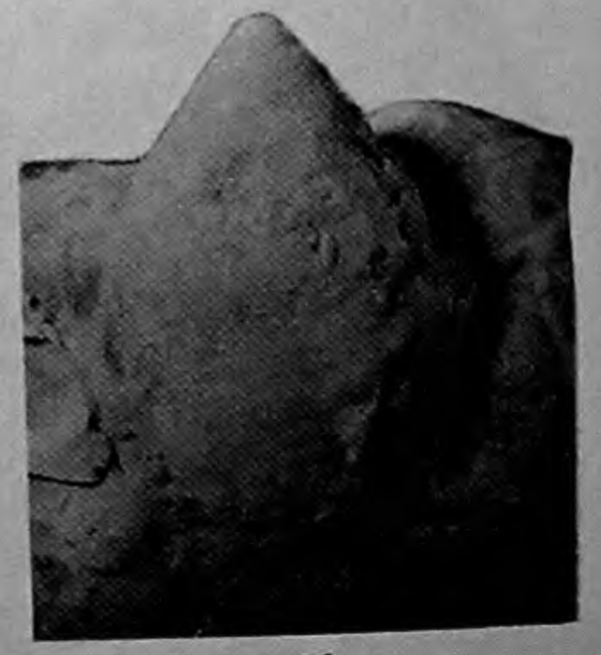

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shell concentrically striated; margins smooth; ligament external on a prominent ridge; an obscure cardinal tooth in each valve; pallial sinus very deep; epidermis conspicuous. **Jura.–Recent.**

P. decisa Conrad (*sl*) (**172**—21, 22). At times the concentric undulations become almost obsolete both anteriorly and posteriorly. **U. Cret.** (*Exogyra ponderosa* and *E. costata* zones): Atlantic and Gulf Coastal Plain.

P. (Panope) generosa Gould (**172**—20). Umbo moderate to prominent. **Mioc.:** Wash. to Cal.; **Plioc.:** Ore. to L. Cal.; Japan; **Pleist.:** Cal.; L. Cal.; **Recent:** Puget Sound to L. Cal.; Japan.

CLASS GASTROPODA[1]

Gastropods or snails are marine, fresh-water, or terrestrial mollusks with a well developed head that usually bears tentacles, eyes, and a mouth furnished with a filelike lingual ribbon or *radula*. They differ from other mollusks in having undergone flexure of the visceral organs, as have some other classes, and also torsion of the visceral mass which, in all but the most primitive of them, has resulted in a decided asymmetry. These features appear in order in the life history of each individual and seemingly in the same order in the history of the class. Ventrally the animal is provided with a muscular "foot" which is generally a broad expansion that may be variously modified. Typically the visceral organs are protected by an external calcareous shell (**174**—1) secreted by the mantle, but the shell may degenerate and become internal or fail to develop at all. The shell may be conical or saucer-shaped, but it is usually coiled into a spiral, either right-handed or left-handed (un-

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[1] In the following brief bibliography few references to Paleozoic gastropods are included because of the comprehensive treatment by Knight in his Genotype monograph. There are also relatively few references to Cenozoic genera since so many of these are still extant and commonly are considered in the literature dealing with modern shells — a literature much too voluminous to list in the present work. Following the references is a short list of other authors who have contributed to the knowledge of fossil gastropods. It is believed that by using the references given here and by consulting the works of the authors in the appended list, the serious investigator can soon compile a bibliography suitable for his own specific needs.

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In addition to the above references, numerous descriptions and illustrations of gastropods will be found among the writings of the following: Aldrich, T. H., Arnold, R., Beede, J. W., Billings, E., Cossmann, M., Gabb, W. M., Girty, G. H., Grabau, A. W., Gregorio, A. de, Hall, J., Heilprin, A., Holmes, F. S., Johnson, C. W., Maury, C. J., Meek, B. F., and Worthen, A. H., Raymond, P. E., Tuomey, M., Whiteaves, J. F., and Whitfield, R. P.

PLATE 174

[Figures are x1 unless otherwise indicated; JBK = original print from J. B. Knight.]

1. A diagrammatic sketch showing numerous features of a gastropod shell [original: R. R. Shrock]. The drawing is based on a diagram prepared by R. B. Stewart and modified in a few details by J. B. Knight. **2, 3. Tryblidium** spp. [JBK]. **2. T. manitoulini.** Left side of holotype (x2). **3. T. striatum.** Dorsal view of a squeeze from the holotype (x2). **4–11. Proplina** spp. **4–6. P. acuta** [AMNH, B 2]. Three views of a specimen. **7, 8. P. unguiformis** [Minn G S 3 (2)]. Dorsal and profile views. **9, 10. P. barabuensis** [Wis G S 4]. Dorsal and side views of a large specimen. **11. P. cornutaformis** [JBK]. Dorsal view, apex upward, of holotype (x4).

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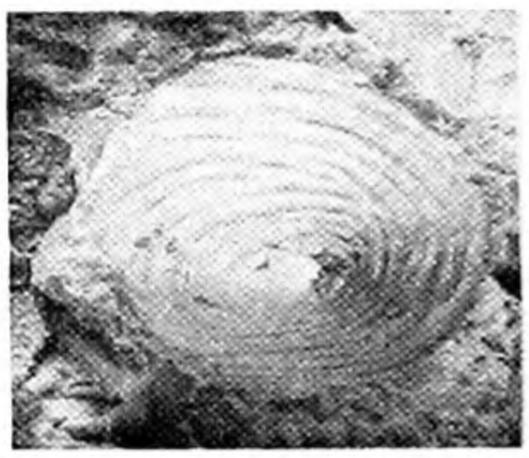

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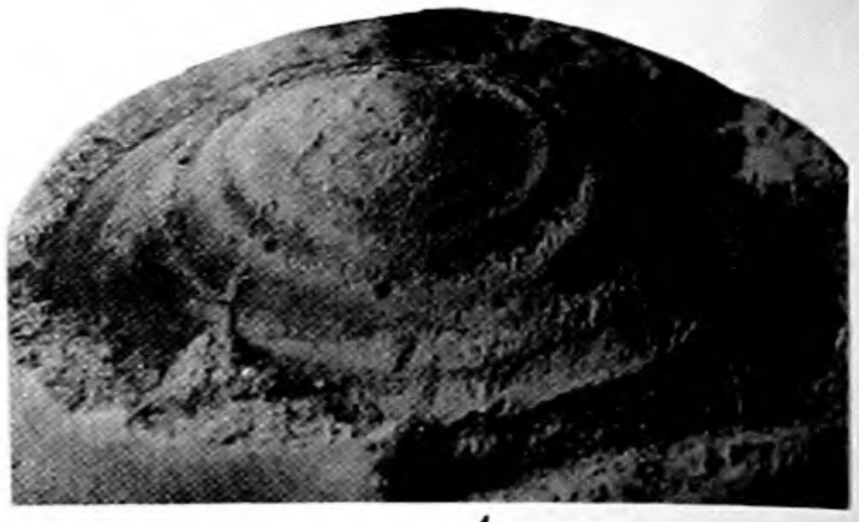

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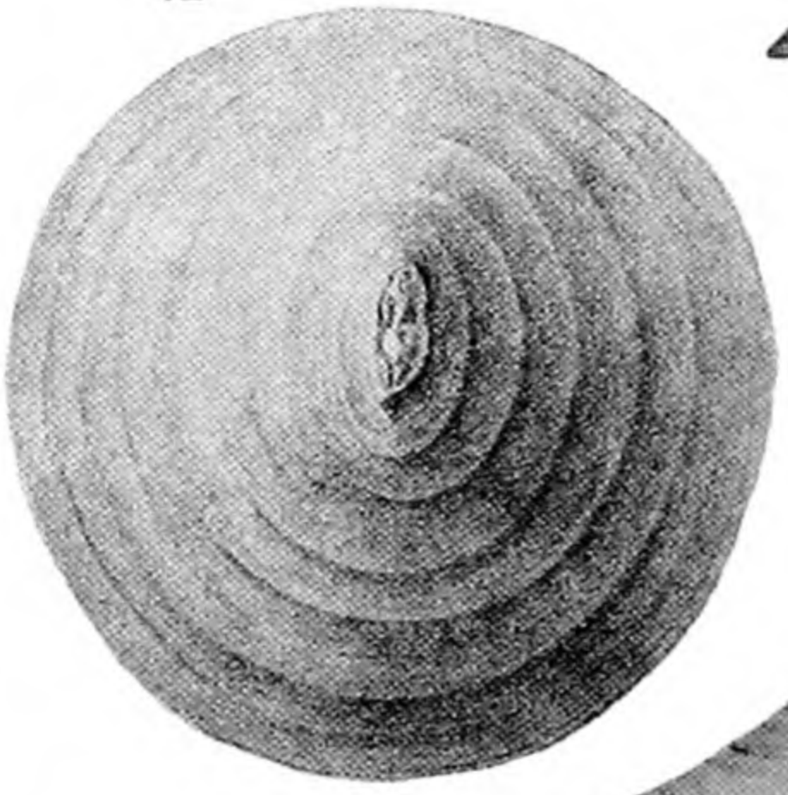

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common). Fundamentally the shell is a gradually enlarging cone typically coiled around an imaginary axis. If the coils are not in contact along the axis, an opening called the *umbilicus* is formed. This varies greatly in size and may be wholly or partly filled with shell matter known as a *callus* formed by a thickening on the inner lip (Naticidae).

The gastropod shell begins as a minute cap-shaped *protoconch* which, through the more rapid addition of shell matter to the outer lip, coils to form the embryonic shell or *nucleus* and often lacks obvious lines of growth. In many genera the nucleus is quite different from the rest of the shell. From the nucleus, which is found at the apex of the spire, the whorls of the shell gradually increase in size. Normally they are circular in section although the basic plan is often modified. The spire may be high with a small angle between its sides or low with a large angle, or the shell may be coiled approximately in a plane, either laterally or dorsally, with no spire at all. In the last case the nucleus is at the center of the coil. The whorls are commonly in contact with each other and the later whorls may embrace the earlier, even to the extent of completely covering them. In some cases the whorls are free or out of contact. The line on the surface marking the outer edge of the area of contact is the *suture*. If there is an angulation in the profile of the whorl in its upper half the space between it and the suture constitutes the *shoulder*. The shoulder angle may be simple or keeled, or furnished with nodes or spines.

The shell grows by accretions of shell matter secreted by the mantle at the margins of the aperture, and the marks of the increments or *growth lines* are of great importance in determining the form of the aperture in fossil shells. The ornamentation of the shell is also formed at the margin of the aperture. This consists of revolving features such as ridges and spirals, formed by continuous specialization of parts of the mantle margin and of features transverse to the whorls such as folds, ribs, or varices formed by periodic specialization. The periodic features may be confined to a definite region of the shell such as the shoulder angle, where they may result in a revolving row or rows of nodes or spines, or they may be more evenly distributed with resulting emphasis on transverse alignment. The spacing between the periodic transverse features usually increases uniformly. Irregular spines may also arise on various parts of the shell surface (*Platyceras*).

The apertural margin of the shell, or *peristome*, may be simple or variously modified. An *outer* and *inner lip* are generally recognized, and the inner lip may be subdivided into a lower part, the *columellar lip*, and an upper part, the *parietal lip*. The parietal lip commonly is covered with a layer of shell matter deposited over the surface of the previous whorl. This layer, which is sometimes called the *inductura* or more commonly when it is thick the *parietal callus*, may be thick, thin, or wanting. The outer and inner lips may be continuous with each other or divided by an *anterior notch* for the protrusion of the *siphon* — a fold in the mantle of some gastropods through which clean water is drawn into the mantle cavity containing the gills. The maagins of the siphonal notch are in some genera (*Fusus*) built out to form an *anterior canal*. A posterior notch is present in some forms (*Cypraea*). Some groups have a deep sinus in the outer lip (*Loxonema*) and others a notch or even a deep *slit* (Pleurotomariidae, Bellerophontidae, Turridae, *etc.*) either as the culmination of the sinus or alone. The function of the notch or slit and perhaps of the sinus appears to be for the extrusion of the anal tube or at least for the flushing out of the faeces. The progressive closing of the notch or slit or in some cases even of an angular sinus leaves a marked band of crescent-shaped lunulae, the *selenizone*. Rarely the formation of the slit is abandoned and the slit is then left as a hole (*Fissuridea*) or by periodic renewal as a succession of holes (*Haliotis, Tremanotus*). The successive emarginations commonly are indicated on the sides of the shell by the course of the growth lines. On the inside of the outer lip various ridges or *teeth* may occur. Similar ridges or teeth more commonly occur on the inner lip particularly where a siphonal notch or canal is present. In some forms (*Nerinea*) the ridges on outer and inner lips combine to fill the whorl nearly full, leaving only a very narrow tortuous opening. The ridges may be few or numerous, readily visible or so far within as to be invisible except in broken shells, or they may be resorbed deep within the shell.

Most living shells are covered with a horny, smooth, or hairy *periostracum* which hides the often brilliant color markings. This periostracum, as well as the coloration, is rarely preserved on fossil shells. The shell proper is typically composed of two layers, the outer one usually prismatic and of calcite and the inner one lamellar, pearly, or *porcelaneous* and

PLATE 175

[Figures are x1 and original by Knight unless otherwise indicated.]

1–3. Scenella spp. (x4). **1, 2. S. acadica.** Part of a specimen showing apex; top view. **3. S. reticulata.** Oblique view of holotype with apex broken away. **4. Palaeacmaea typica.** Oblique side view of squeeze from holotype (x2). **5–9. Helcionella subrugosa** [USGS, B 30 and An Rp 10]. Top view; side and diagrammatic top views; side views of two coarsely annulated specimens. **10. Helcionella subrugosa.** Oblique view of holotype (x4). **11–13. Palaeacmaea** spp. **11. P. quebecensis** (x0.5) [CGS, Pal Foss 1]. **12, 13. P. irvingi** [Wis G S 4]. Side and top views. **14–16. Hypseloconus** spp. **14, 15. H. recurvus** [Wis G S 4]. Side and top views of a large specimen. **16. H. elongatus.** Right side view of a paratype (x2). **17–19. Pelagiella** spp. **17, 18. P. atlantoides** (x6). Top view of specimen with apex broken — the holotype; side view of a paratype. **19. P. hoyti** [SMC 57]. Side view of type specimen (x6). **20. Matherella saratogensis.** Apertural view of holotype (x4). **21–23. Scaevogyra swezeyi.** Apertural view of a paratype and side view of holotype showing shape of outer lip; top view of another specimen [GSA, B 43; print furnished by J. Bridge]. **24–27. Cyrtolites** spp. [Minn G S 3 (2)]. **24, 25. C. ornatus.** Side view; portion of another speciman enlarged (x10). **26, 27. C. retrorsus.** Side and apertural views of a large specimen.

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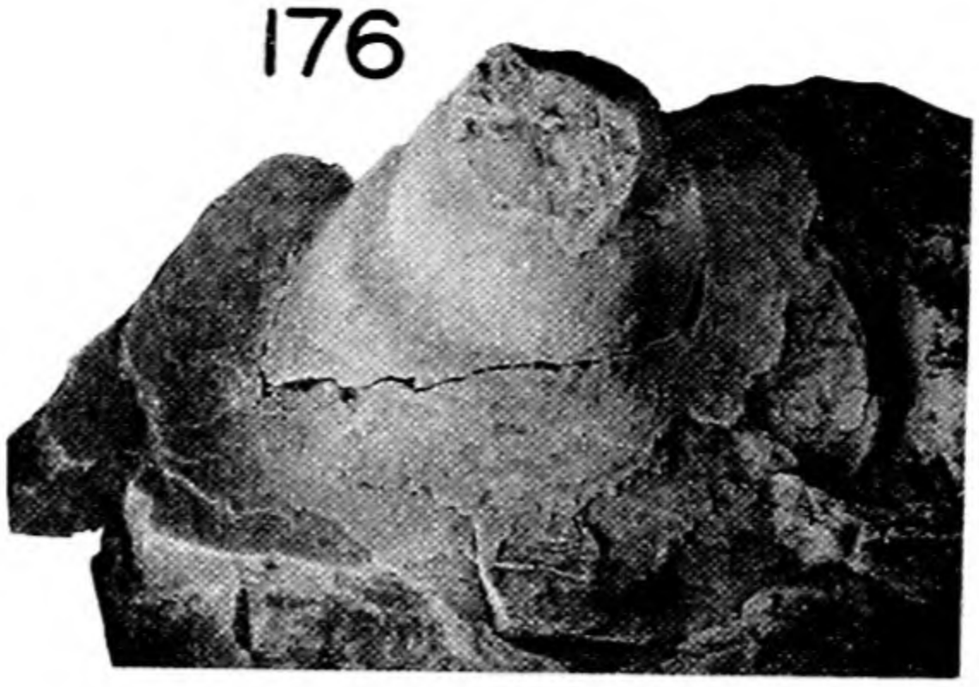

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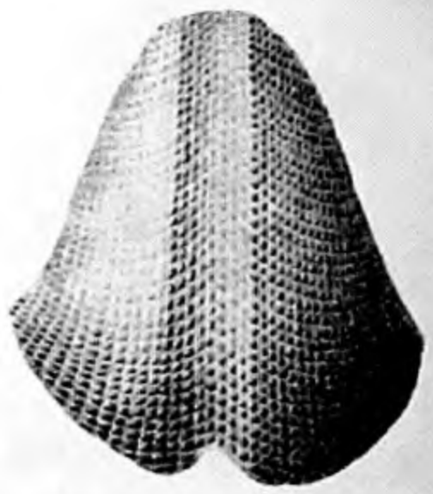

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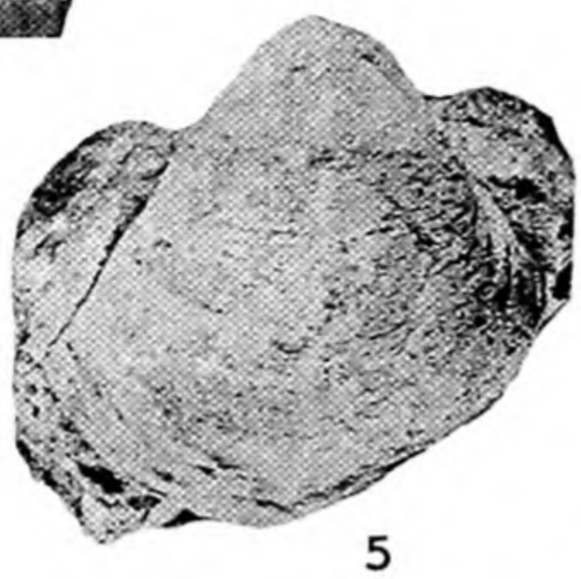

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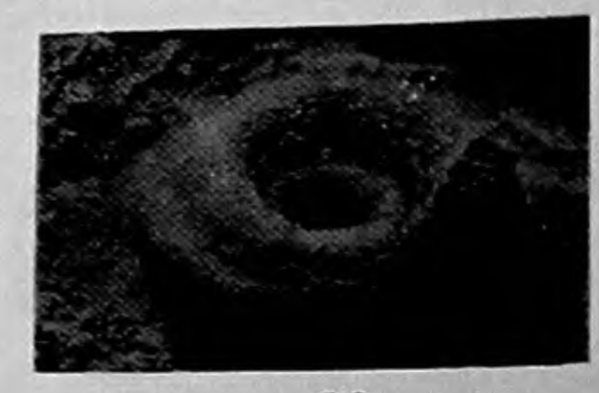

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usually of aragonite. In some species the entire shell may be aragonitic.

The shell of the gastropod is carried with the spire backward and to the right with the aperture down. The outer lip (in dextral shells) is then on the right and right anterior sides of the animal and the columellar lip on the left but not visible. The siphonal notch or canal when present is directed to the front or a little to the left of the front. In figuring or describing shells most authors place the apex (posterior) upward and the aperture open to the observer, but many European paleontologists orient the shell with the apex down.

The aperture is commonly closed by a horny *operculum* which in some forms has a calcareous deposit on its outer side. This calcareous deposit may be very thick in proportion to its horny base. The operculum varies greatly in form in different genera. It is attached to the upper posterior surface of the foot. Gastropod opercula with heavy calcareous deposits are not uncommon as fossils in the Paleozoic, and some (*Ceratopea*) are useful as index fossils even if the shell to which they belong is unknown.

Since the gastropod shell, in large part, is composed of relatively soluble aragonite, it is not so often well preserved as are the wholly calcitic shells of brachiopods. Particularly in the older rocks, many gastropod fossils are merely fillings of the shell interior. It is very important that the student does not mistake such fillings for replicas of the outer surface of the shell and that he exercise extreme caution in using them, for in many wholly unrelated gastropods of all ages internal fillings are indistinguishable from one another. On the other hand, some fillings are sufficiently distinctive that the careful worker can distinguish them at least generically and use them profitably.

PALEOZOIC GASTROPODA

REVISED BY J. BROOKES KNIGHT, WITH THE COLLABORATION OF JOSIAH BRIDGE AND THE AUTHORS

Subclass Protogastropoda

Order Cynostraca

PROPLINA Kobayashi 1933

(**Metoptoma cornutaforme* Walcott). Patelliform or cap-shaped with apex generally rather high above anterior (?) end and overhanging it; aperture ovoid, anterior (?) end the narrower; muscle scars unknown, but probably discrete and paired; ornamentation, concentric lines of growth. **Camb., Ord.** (widely distributed).

***P. cornutaformis** (Walcott) (**174**—11). **Camb.** (Franconia): Eastern U. S. A.

P. barabuensis (Whitfield) (**174**—9, 10). **Camb.** (Trempealeau): U. Mississippi Valley.

P. acuta (Whitfield) (**174**—4–6). **Ord.** (Canadian): Northeastern U. S. A.

P. unguiformis (Ulrich and Scofield) (**174**—7, 8). **Ord.** (Mohawkian): Mississippi Valley.

TRYBLIDIUM Lindstroem 1880

(= HELCIONOPSIS Ulrich and Scofield 1897; VALLATOTHECA Foerste 1914; PILINA Koken 1925)

(**T. reticulatum*). Patelliform shells with convex upper surface and apex close to and often overhanging anterior end; aperture ovoid, anterior end the narrower; muscle scars discrete, in six pairs; ornamentation varied, the concentric being composed of growth lines, in some species strongly lamellar or of radiating lirae. **Ord., Sil.** (widely distributed).

T. manitoulini (Foerste) (**174**—2). **Ord.** (Richmond): Eastern Canada.

T. striatum (Ulrich and Scofield) (**174**—3). **Ord.** (Cincinnatian): Mississippi Valley.

SCENELLA Billings 1872

(= PARMOPHORELLA Matthew 1886)

(**S. reticulata*). Patelliform or cap-shaped with apex tilted toward one end (the anterior?); aperture subelliptical; muscle scars unknown; ornamentation wavy, concentric undulations and fine radial lirae. **Camb.** (widely distributed).

***S. reticulata** Billings (**175**—3). **L. Camb.:** Northeastern N. America.

S. acadica (Dawson) (**175**—1, 2). **L. Camb.:** Eastern Canada.

PALAEACMAEA Hall and Whitfield 1872

(**P. typica*). Patelliform shells with conical form and subcentral apex; aperture subcircular or faintly subelliptical; apex seemingly erect; muscle scars unknown; ornamentation, concentric undulations. **Camb., Ord.** (widely distributed).

***P. typica** H and W (**175**—4). **U. Camb.** (Potsdam): Eastern N. America.

P. irvingi Whitfield (**175**—12, 13). **U. Camb.:** U. Mississippi Valley.

PLATE 176

[Figures are x1 and original by Knight unless otherwise indicated.]

1, 2. Clisiospira curiosa. Side view of a paratype showing ornamentation (x4); oblique view of holotype showing basal frill (x2). **3–6. Cyrtonella mitella.** 3, 4: Back views showing ornamentation and prominent groove (x3, x4) [Pal N Y 5 (2)]. 5, 6: Dorsal view of holotype (x2) and side view of another specimen (x2) [GSA, SP 32]. **7, 8. Owenella antiquatus.** Anterior and oblique views of a hypotype (x10). **9–20. Bucanella spp. 9–14. B. cordiformis** [JP 9]. Side, apertural, and back views of holotype (x2, x1). **15, 16. B. trilobata** [Pal N Y 2]. Side and back views. **17. B. brevilineata** [Pal N Y 5 (2)]. An imperfect specimen (x2). **18–20. B. nana** (x8). Two views of holotype and oblique side view of a paratype. **21–25. Sinuites spp. 21–23. S. rectangularis** [Minn G S 3 (2)]. Dorsal and side views of a specimen; side view of a very large shell. **24, 25. S. cancellatus** the type of *Protowarthia*. Side view of the crushed holotype (x4); dorsal view of a hypotype (x2).

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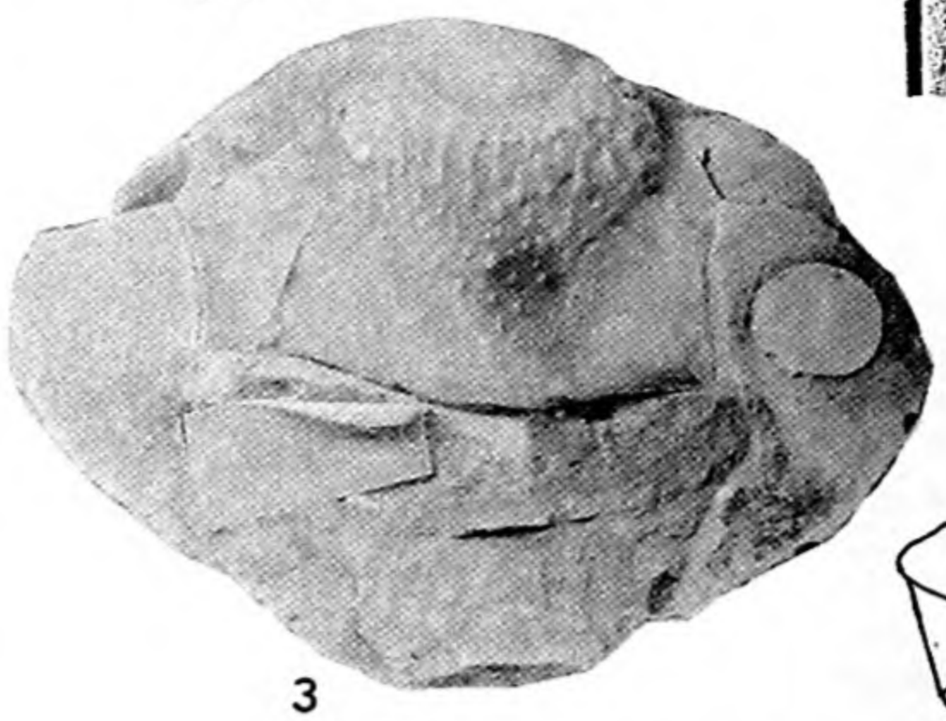

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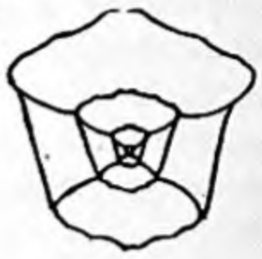

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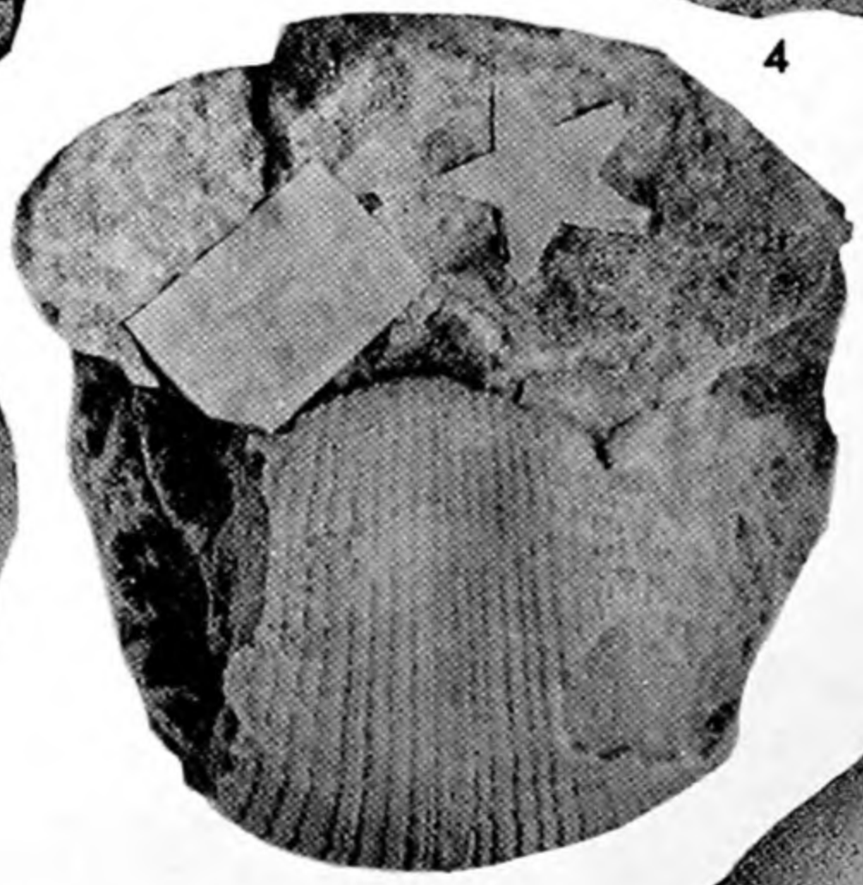

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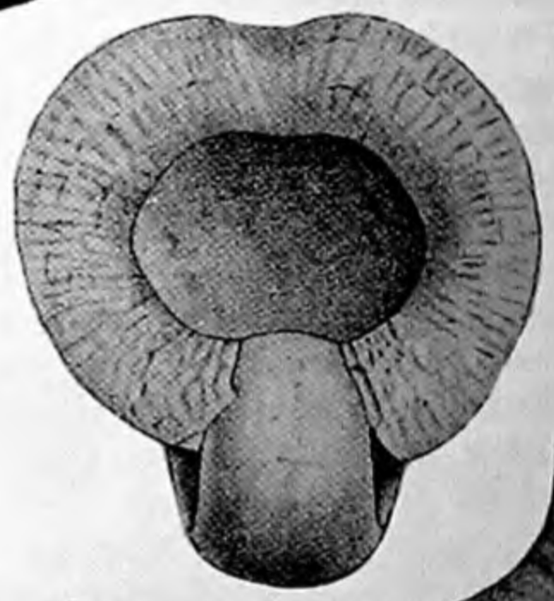

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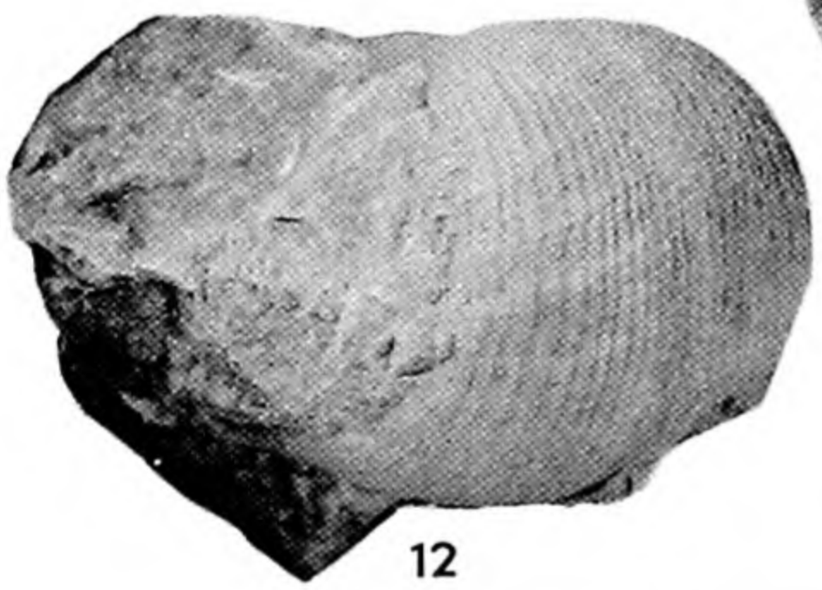

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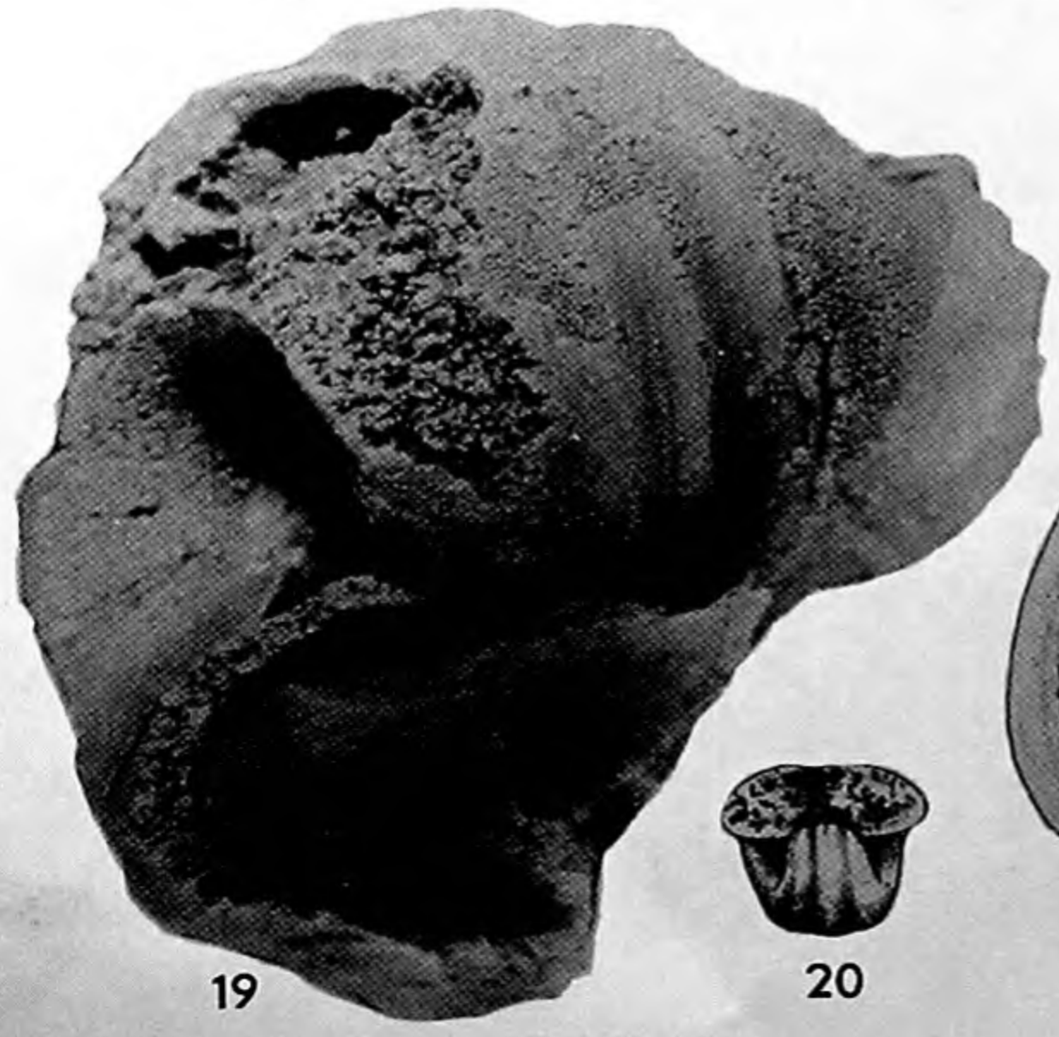

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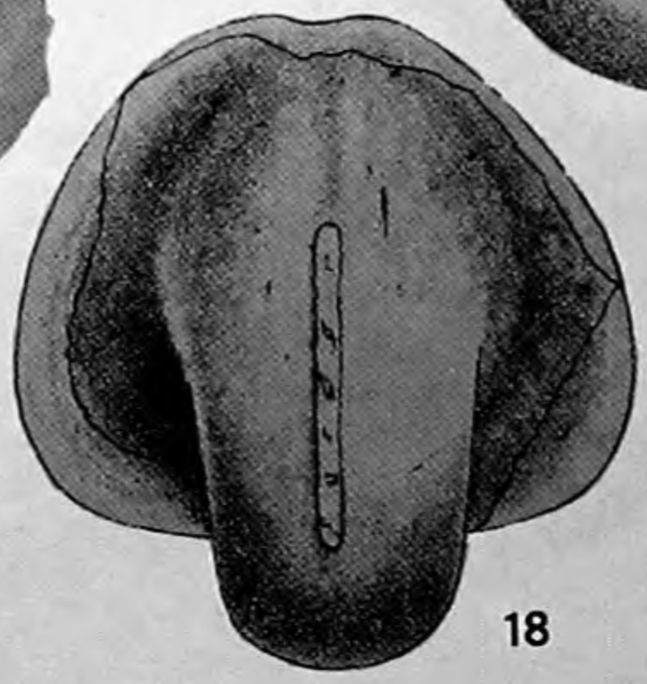

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P. quebecensis (Billings) (**175**—11). **Ord.** (Canadian): Eastern Canada.

HYPSELOCONUS Berkey 1898

(**H. recurvus elongatus*). Moderately to very high conical shells with pointed apex situated over narrower end of shell but recurved toward broader end; aperture suboval; muscle scars unknown; ornamentation, growth lines and faint radial striae. **Camb.** (N. America).

***H. elongatus** Berkey (**175**—16). **Camb.** (Franconia): U. Mississippi Valley.

H. recurvus Whitfield (**175**—14, 15). **Camb.** (Trempealeau): U. Mississippi Valley.

HELCIONELLA Grabau and Shimer 1909

(**Metoptoma rugosum* Hall). Patelliform shells often with a high, liberty-cap shape and with apex titled toward one end (the anterior?); aperture subelliptical; muscle scars unknown; ornamentation, strong rugose concentric undulations and finer growth lines, commonly obsolescent under curved apex. **Camb.** (widely distributed).

***H. subrugosa** (Orbigny) (= **M. rugosum** Hall) (**175**—5–10). **L. Camb.:** Eastern N. America.

Order Cochliostraca

PELAGIELLA Matthew 1895

(= PARAPELAGIELLA Kobayashi 1939;

PROECCYLIOPTERUS Kobayashi 1939)

(**Cyrtolithes atlantoides*). Very small shells with few whorls, not always in contact, a flattened upper surface and a convex lower surface; apertural margin without sinus; ornamentation, growth lines, in some species supplemented with faint revolving lirae. **Camb.** (widely distributed).

***P. atlantoides** (Matthew) (**175**—17, 18). **L. Camb.:** Northeastern N. America.

P. hoyti (Walcott) (**175**—19). **U. Camb.:** Eastern U. S. A.

SCAEVOGYRA Whitfield 1878

(= VERSISPIRA Perner 1903;

KOBAYASHIELLA Endo 1937)

(**S. swezeyi*). Sinistral shells with whorls that are broadly rounded above and narrowly rounded below; outer lip oblique; base umbilicate; ornamentation, growth lines, and in some species rounded transverse costae. **U. Camb., Ord.** (widely distributed).

***S. swezeyi** Whitfield (**175**—21–23). **Camb.** (Trempealeau and equivalents): Eastern and central U. S. A. (Va. to Ala., Wis., Mo., Tex.).

MATHERELLA Walcott 1912

(= BILLINGSIA Miller 1889)

(**Billingsia saratogensis* Miller). Trochiform, sinistral shells with moderately high spire and whorls that are flatly rounded on sides and narrowly rounded below; base with umbilicus (or pseudo-umbilicus?); outer lip oblique, without sinus; ornamentation, growth lines. **Camb.** (N. America).

***M. saratogensis** (Miller) (**175**—20). **U. Camb.:** Eastern U. S. A.

CLISIOSPIRA Billings 1865

(= MIMOSPIRA Koken 1925)

(**C. curiosa*). Conical, sinistral shells with a frill surrounding base which seemingly is concave and incomplete at late stages; outer lip strongly oblique; ornamentation, transverse growth lines or lirae, in some species revolving lirae as well. **Ord.** (widespread).

***C. curiosa** Billings (**176**—1, 2). **Canadian;** Eastern Canada.

Subclass Eugastropoda

Superorder Prosobranchia

Order Archaeogastropoda

CYRTOLITES Conrad 1838

(= MICROCERAS Hall 1845;

DISCOLITES Emmons 1855)

(**C. ornatus*). Bellerophontid shells with final whorls free or only slightly in contact; carinate dorsally and usually with angular sides and transverse plicae; aperture with very slight sinus or none at all; slit and selenizone absent; ornamentation, very fine revolving and transverse lirae forming a close network. **Ord.** (widely distributed).

C. retrorsus Ulrich and Scofield (**175**—26, 27). **Ord.** (Trenton): Eastern and central U. S. A.

***C. ornatus** Conrad (**175**—24, 25). **Ord.** (Maysville–Richmond): Canada; eastern and central U. S. A.

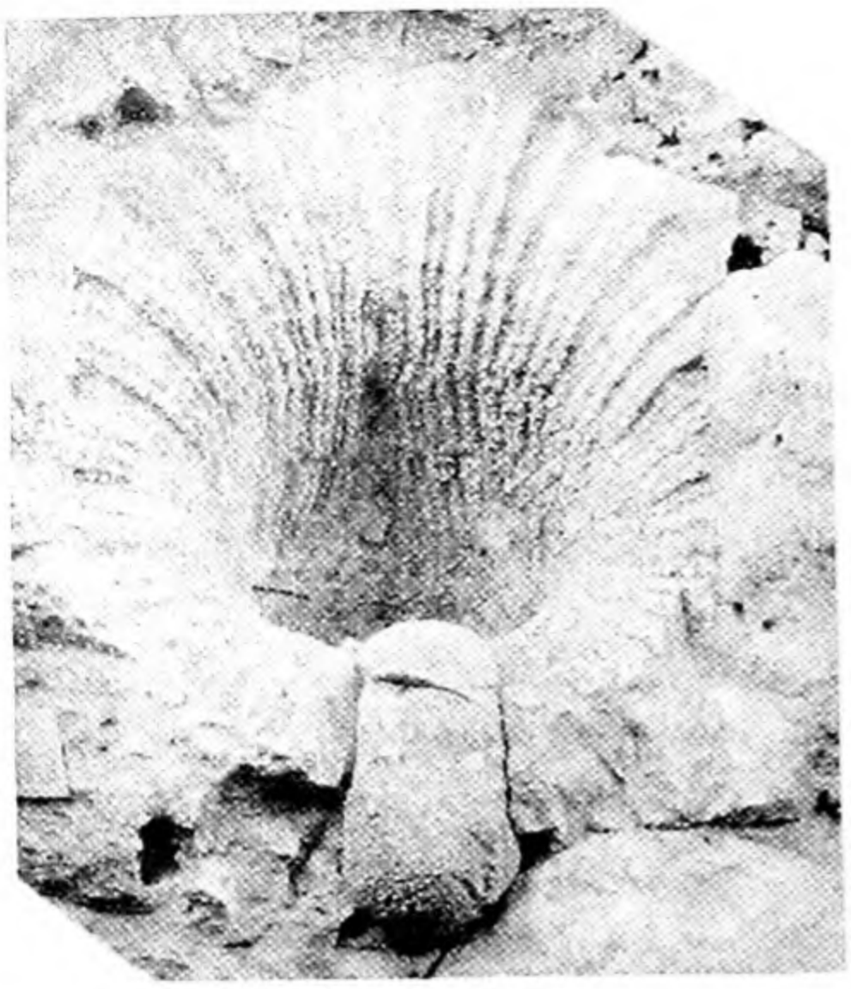
CYRTONELLA Hall 1879

(**Cyrtolites? mitella*). Bellerophontid shells with final whorl free or only slightly in contact; slightly carinate dorsally with rounded whorls; aperture without sinus, slit, or selenizone; ornamentation, moderately strong transverse growth lines with fine revolving lirae between; usually with an asymmetrical indentation in posterior part of final whorl;

PLATE 177

[Figures are x1 and original by Knight unless otherwise indicated.]

1–4. Ptomatis patulus. Dorsal view of a rugose hypotype (x2); apertural view of a hypotype; view of pustulose parietal inductura (x2); dorsal view of a rather smooth hypotype. **5–8. Bucania costalis** [Minn G S 3 (2)]. Portion of broad dorsal band and right slope (x3); transverse section of last whorl, lower side dorsal; lateral and dorsal views of type. **9–11. Tetranota sexcarinata** [Minn G S 3 (2)]. Section of a shell; two views of an internal filling. **12, 13. Bucania sulcatina** (x2). Oblique dorsal view of a specimen; apertural view of the probable holotype. **14–18. Salpingostoma** spp. [Minn G S 3 (2)] **14–16. S. buelli.** Apertural, side, and dorsal views. **17, 18. S. richmondense.** Side and dorsal views. **19. Tetranota bidorsata.** Oblique apertural view of holotype (x4). **20, 21. Tetranota obsoleta** [Minn G S (3 2)]. Two views of the supposed type.



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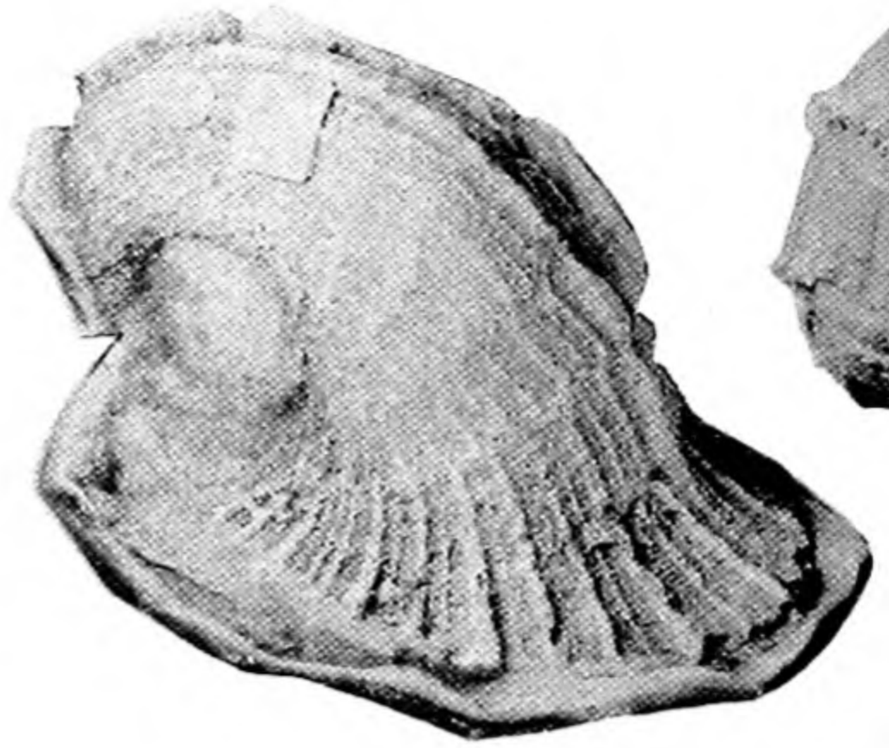

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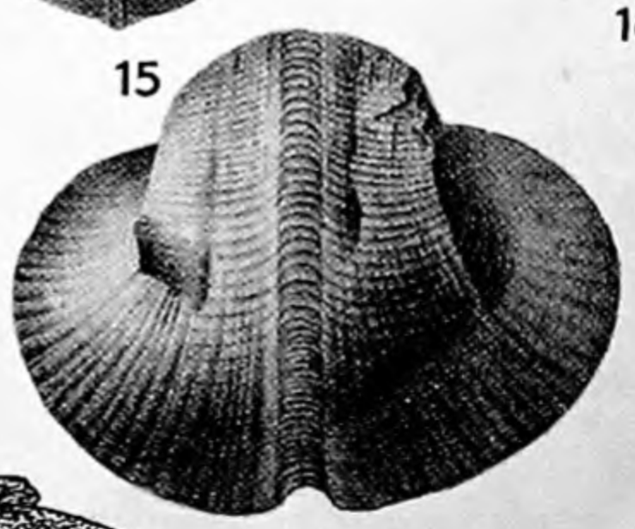

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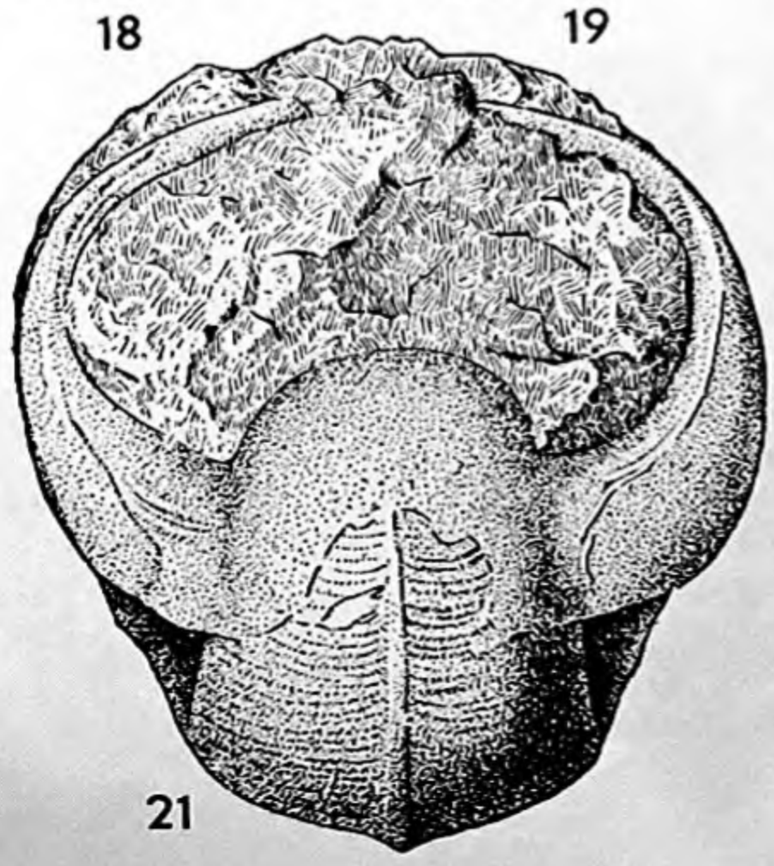

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two pairs of dorsal muscle scars. **Sil., Dev.** (N. America; Europe).

***C. mitella** (Hall) (**176**—3–6). **M. Dev.:** Eastern and central U. S. A.

OWENELLA Ulrich and Scofield 1897

(**Bellerophon antiquatus* Whitfield). Subglobose bellerophontid shells with rounded outer surface and gradually enlarging, dorsoventrally compressed, closely coiled whorls; umbilici open; anterior lip with sharp but shallow rounded sinus; no slit or selenizone. **U. Camb.** (widespread in U. S. A.)

***O. antiquatus** (Whitfield) (**176**—7, 8). **U. Camb.** (Trempealeau and equivalents): U. Mississippi Valley, Tex., Nev.

SINUITES Koken 1896

(= PROTOWARTHIA Ulrich and Scofield 1897)

(**Bellerophon bilobatus* Sowerby). Bellerophontid shells with large but not expanding aperture and rather deeply embracing whorls; umbilici narrow or closed; a deep, rounded sinus in anterior lip but no slit or selenizone; ornamentation, fine lines of growth and in some species fine revolving lirae. **Ord.** (widespread).

S. rectangularis (Ulrich and Scofield) (**176**—21–23). **Ord.** (Black River): U. Mississippi Valley.

S. cancellatus (Hall) (**176**—24, 25). **Ord.** (Trenton–Richmond): Eastern Canada and U. S. A., chiefly in the Trenton.

BUCANELLA Meek 1871

(= PLECTONOTUS Clarke 1899)

(**B. nana*). Bellerophontid shells with more or less trilobed dorsum; umbilici open showing inner whorls, in some species very wide; apertural margins not flaring; a deep, narrow sinus in anterior lip but no slit or selenizone; ornamentation, transverse lirae or growth lines and in some species revolving lirae. **Ord.–Penn.** (widespread).

***B. nana** Meek (**176**—18–20). Small, deeply trilobed, without revolving lirae. **Ord.:** Colo.

B. trilobata (Conrad) (**176**—15, 16). Small, with revolving lirae. **Sil.:** Eastern Canada and U. S. A.

B. brevilineata (Conrad) (**176**—17). Larger, lines of growth often indistinct. **Dev.** (Hamilton): N. Y.

B. cordiformis (Newell) (**176**—9–14). **Penn.** (Lansing): Kan.

PTOMATIS Clarke 1899

(**Bellerophon patulus* Hall). Bellerophontid shells with widely explanate aperture and with a narrow, shallow sinus in anterior lip; no slit or selenizone; umbilici plugged with callus; parietal inductura thickened and forming a bluntly rounded platform within aperture, thinner at other points. **Dev.** (N. and S. America).

***P. patulus** (Hall) (**177**—1–4). **Dev.** (Hamilton): Eastern and central U. S. A.

BUCANIA Hall 1847

(= KOKENIA Ulrich and Scofield 1897; KOKENOSPIRA Bassler 1915)

(**Bellerophon sulcatinus* Emmons). Shell bellerophontid with wide umbilici; whorls depressed or broadly carinate; apertural margin not expanding rapidly, with broad sinus in anterior lip that culminates in a slit which generates a selenizone; ornamentation, continuous revolving lirae and transverse growth lines. **Ord., Sil.** (widespread).

***B. sulcatina** (Emmons) (**177**—12, 13). **Ord.** (Chazyan): Eastern U. S. A.

B. costalis Ulrich and Scofield (**177**—5–8). **Ord.** (Trenton): Minn.

TETRANOTA Ulrich and Scofield 1897

(**Bucania bidorsata* Hall). Bellerophontid shells with dorsoventrally compressed whorls with one or more subangular revolving ridges on each side of selenizone; apertural margin not flaring, with a rather deep anterior sinus culminating in a short slit that generates the selenizone; umbilici moderately wide and deep; ornamentation, growth lines and fine revolving lirae. **Ord.** (widespread).

***T. bidorsata** (Hall) (**177**—19). **Ord.** (Stones River–Trenton): Eastern Canada; widespread in eastern and central U. S. A.

T. sexcarinata Ulrich and Scofield (**177**—9–11). Six revolving ridges; lines of growth strong. **Ord.** (Stones River–Trenton): Mississippi Valley.

T. obsoleta Ulrich and Scofield (**177**—20, 21). Revolving ridges weakly developed especially on last volution. **Ord.** (Black River–Trenton): Mississippi Valley.

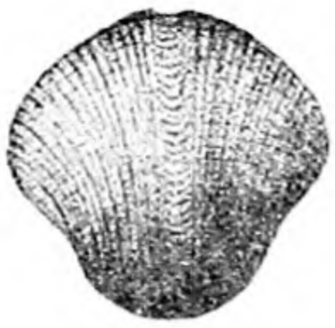
SALPINGOSTOMA Roemer 1876

(**Bellerophon megalostoma* Eichwald). Bellerophontid shells with scarcely embracing whorls and wide, shallow umbilici; apertural margins flaring widely on all sides in mature shells with only a shallow sinus at anterior margin; at earlier stages a shallow sinus culminates in a deep slit that generates a selenizone on earlier whorls; at mature stages poste-

PLATE 178

[Figures are x1 and original by Knight unless otherwise indicated.]

1, 2. Tremanotus alpheus. A partial external impression and a squeeze from a similar specimen. **3–7. Phragmolites** spp. **3, 4. P. obliquus.** Side and anterodorsal views of the holotype of *Conradella* (x4). **5. P. compressus.** Side view of a hypotype (x2). **6, 7. P. fimbriatus** [Minn G S 3 (2)]. Two views of a large specimen. **8–11. Tropidodiscus** spp. **8, 9. T. subacutus** [Minn G S 3 (2)]. Apertural and lateral views. **10, 11. T. curvilineatus.** Oblique apertural view and side view of holotype (x2). **12–22. Bellerophon** spp. **12–14. B. troosti** [Minn G S 3 (2)]. Three views of a nearly entire specimen. **15–17. B. pelops** [Pal N Y 5 (2)]. Apertural view of an incomplete specimen (x2); dorsal and side views of a specimen enlarged several times. **18–20. B. sublaevis** [Ind G S 11]. Side, dorsal, and apertural views. **21, 22. B. crassus** [Ind G S 13]. Apertural and lateral views. **23. Bucanopsis leda** [Pal N Y 5 (2)]. Dorsal view (x2). **24, 25. Bucanopsis carinifera.** Anterior views of two paratypes (x4).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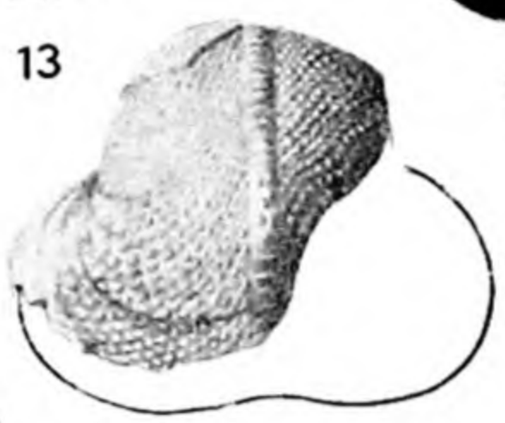
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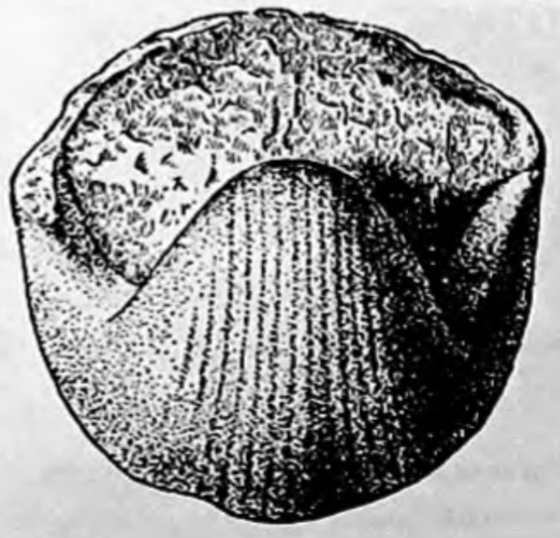
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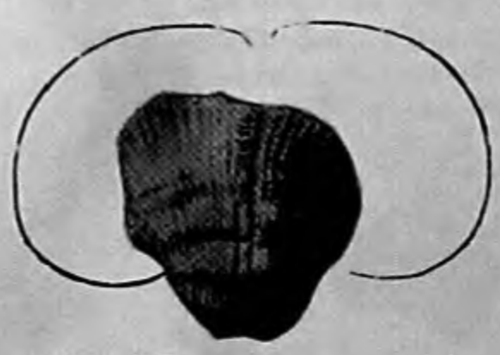
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rior portion of slit remains open but it is closed at its anterior end and does not reach or cross expansion of lip. **Ord.** (widespread).

S. buelli Whitfield (**177**—14–16). **Ord.** (Black River): U. Mississippi Valley.

S. richmondense Ulrich and Scofield (**177**—17, 18). **Ord.** (Richmond): Mississippi Valley.

TREMANOTUS Hall 1875

(= GYROTREMA Lindstroem 1884)

(**T. alpheus*). Bellerophontid shells with scarcely embracing whorls and wide shallow umbilici; apertural margin flaring widely; no sinus or slit in flaring margin but a row of holes (*tremata*) along dorsum replace slit; ornamentation, revolving ribs and periodic transverse growth lines. **Sil., L. Dev.** (widespread).

***T. alpheus** Hall (**178**—1, 2). **Sil.** (Niagaran): Ont.; N. Y., Mississippi Valley.

PHRAGMOLITES Conrad 1838

(= CONRADELLA Ulrich and Scofield 1897)

(**P. compressus*). Bellerophontid shells with wide umbilici and narrow, fluted, periodic expansions of lip; without sinus in lip but with deep slit which generates a selenizone at crest of a revolving dorsal carina. **Ord.** (widespread).

P. fimbriatus (Ulrich and Scofield) (**178**—6, 7). **Ord.** (Black River): Mississippi Valley.

P. obliquus (Ulrich and Scofield) (**178**—3, 4). **Ord.** (Black River): Northern Mississippi Valley.

***P. compressus** Conrad (**178**—5). **Ord.** (Trenton); Eastern Canada and U. S. A.

TROPIDODISCUS Meek and Worthen 1866

(= TROPIDISCUS Meek 1866; TROPIDOCYCLUS Koninck 1882; OXYDISCUS Koken 1889; CYRTODISCUS Perner 1903; ZONIDISCUS Spitz 1907; JOLEAUDELLA Patte 1929)

(**Bellerophon curvilineatus* Conrad). Laterally compressed, discoidal, bellerophontid shells with a sharp subangular dorsum and moderately wide umbilici; a deep angular sinus in anterior lip culminates in deep slit that generates narrow selenizone at crest of dorsum; parietal inductura thin; ornamentation, fasciculated, sometimes lamellar and sometimes crinkled growth lines, rarely revolving lirae. **Ord.–Dev.** (widespread).

T. subacutus (Ulrich) (**178**—8, 9). **Ord.** (Trenton): Eastern U. S. A. and Mississippi Valley.

***T. curvilineatus** (Conrad) (**178**—10, 11). **Dev.** (Oriskany–Onondaga): Eastern U. S. A.

BELLEROPHON Montfort 1808

(= WAAGENIA Koninck 1882; WAAGENELLA Koninck 1883; PROSOPTYCHUS Perner 1903)

(**B. vasulites*). Subglobular gastropods symmetrically coiled in dorsoventral plane with whorls deeply involute; a broad sinus in anterior lip culminating in slit which generates a selenizone; little or no flare to lip anteriorly but generally some lateral flare; posterior lip forming an inductura covering previous whorl; inductura thickened to pad a short distance within aperture of mature individuals; umbilici narrow, in some species filled with callus; selenizone with or without bordering lirae or it may occupy crest of a low keel; ornamentation, simple growth lines or transverse lirae. **Ord.–Trias.** (worldwide distribution).

B. troosti Orbigny (**178**—12–14). **Ord.** (Trenton): Va., Ky., Tenn.

B. pelops Hall (**178**—15–17). **Dev.** Schoharie and Onondaga of N. Y. and Ohio; Hamilton of Wis.

B. sublaevis Hall (**178**—18–20). **Miss.** (St. Louis–Chester): Mississippi Valley.

B. crassus Meek and Worthen (**178**—21, 22). **Penn.:** Widespread in N. America.

BUCANOPSIS Ulrich and Scofield 1897

(= SPHAEROCYCLUS Perner 1903; TUBOGYRA Perner 1903)

(**B. carinifera*). Like *Bellerophon* in all respects except that ornamentation includes revolving lirae; if transverse growth lines are strong a beautiful cancellated pattern is formed. **Ord.–Trias.** (worldwide distribution).

***B. carinifera** U and S (**178**—24, 25). **Ord.:** Ohio (Maysville), Ky. (Trenton).

B. leda (Hall) (**178**—23). **Dev.** (Hamilton): Ont.; N. Y., Md.

B. textilis (Miller) (**179**—1, 2). **Miss.:** Ind. (Meramec), Ark. (Moorefield), Nev.

B. tenuilineata (Gurley) (**179**—3–5). **Penn.:** Widespread in Mississippi Valley.

B. modesta Girty (**179**—6–8). **Perm.:** N. Mex. (San Andreas).

PLATE 179

[Figures are x1 unless otherwise indicated.]

1–8. Bucanopsis spp. **1, 2. B. textilis** [Ind G S 30]. Dorsal and side views (x2). **3–5. B. tenuilineata** [USGS, B 544]. Three views of a specimen (x2). **6–8. B. modesta** [USGS, B 389]. Three views of a specimen (x2). **9–15. Loxobucania** spp. [Minn G S 3 (2)]. **9, 10. L. lindsleyi.** Dorsal and side views of type. **11–14. L. halli.** Two sections of whorls; dorsal and side views of a specimen retaining surface markings **15. L. punctifrons.** Side view. **16–20. Aglaoglypta** spp. **16–18. A. maera** [Pal N Y 5 (2)]. Dorsal and side views of a specimen; dorsal view of another shell with somewhat coarser ornamentation. **19, 20. A. koeneni** [N Y St Mus, M 6]. Dorsal and side views of an incomplete specimen (x2). **21–26. Pharkidonotus** spp. **21–23. P. tricarinatus** [Ind G S 13]. Three views of a specimen. **24–26. P. percarinatus** (x2) [J. B. Knight original]. Two apertural views and a dorsal view. **27–33. Euphemites** spp. **27, 28. E. lentiformis** [Walker Mus (Chicago), Contr 1 (10)]. **29–31. E. vittatus** [JP 14]. Side, apertural, and dorsal views. **32, 33. E. nodocarinatus** [Ind G S 13]. Apertural and dorsal views. **34–41. Cymatospira montfortianus** [USGS, B 544]. 34, 35: Apertural and dorsal views of a broken specimen with good sculpture; 36–38: Dorsal, apertural, and side views (x2) of a specimen showing the greatly developed callosity; 39: Same as 37 (x3); 40, 41: Two views of an imperfect specimen with flaring aperture restored.

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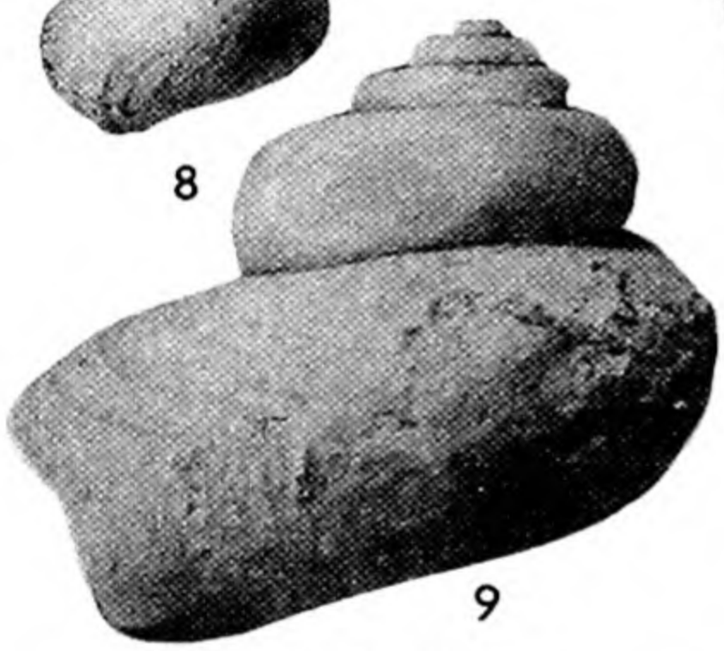

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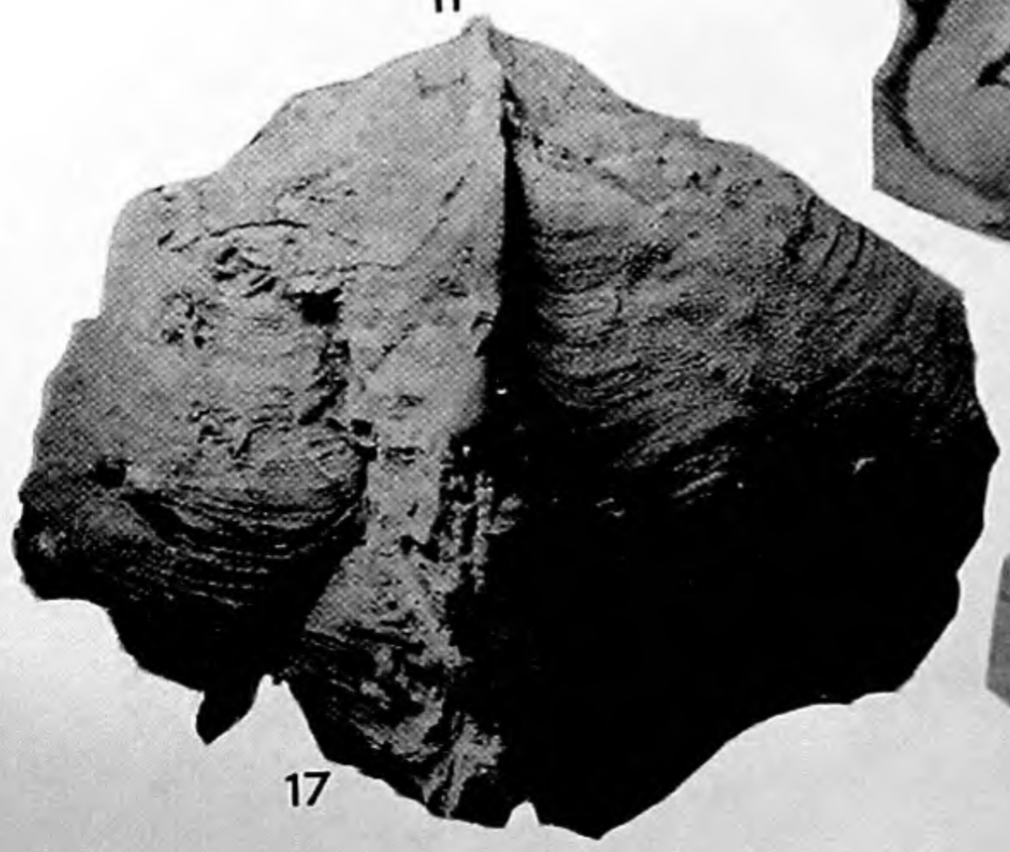

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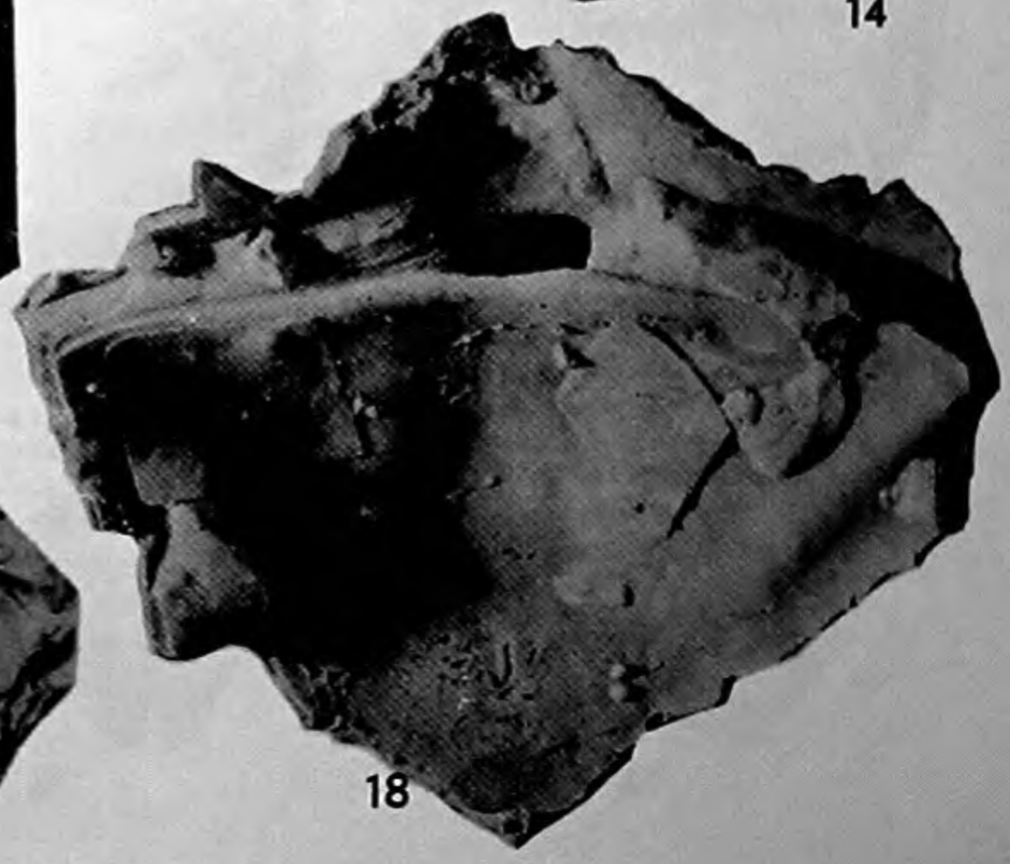

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LOXOBUCANIA Knight 1942

(**Bellerophon lindsleyi* Safford). Shell bellerophontid with moderately wide umbilici; whorls rounded or depressed; apertural margin not expanding rapidly; a broad sinus in anterior lip that culminates in slit which generates selenizone; ornamentation, discontinuous revolving lirae which arise in umbilical region and pass forward and obliquely upward; revolving lirae interrupted by lines or lamellae of growth. **Ord.** (widespread).

***L. lindsleyi** (Safford) (**179**—9, 10). **Ord.** (Trenton): Tenn.

L. halli Ulrich and Scofield (**179**—11–14). **Ord.** (Black River): Mississippi Valley.

L. punctifrons (Emmons) (**179**—15). Oblique network of transverse and revolving elements of ornamentation form quincuncially arranged pits. **Ord.** (Trenton): Eastern Canada and U. S. A.

AGLAOGLYPTA Knight 1942

(**Bellerophon koeneni* Clarke). Like *Bellerophon* in all respects except that ornamentation consists of quincuncially arranged pustules. **M.** and **U. Dev.** (Canada; U. S. A.; Europe).

***A. koeneni** (Clarke) (**179**—19, 20). **Dev.** (Naples): N. Y.

A. maera (Hall) (**179**—16–18). **Dev.** (Chemung): N. Y., Pa.

PHARKIDONOTUS Girty 1912

(**Bellerophon percarinatus* Conrad). Like *Bellerophon* in all respects except that ornamentation consists of transverse plicae formed by fasciculation of growth lines; there is also a tendency toward a shouldering of lateral slopes; selenizone present but faint. **Penn., Perm.** (widespread in N. America; Europe).

***P. percarinatus** (Conrad) (**179**—24–26). **Penn.:** Widespread in N. America.

P. tricarinatus (Shumard) (**179**—21–23). **Penn.:** Widespread in N. America.

EUPHEMITES Warthin 1930

(= EUPHEMUS McCoy 1844)

(**Bellerophon urei* Fleming). Like *Bellerophon* in all respects except that parietal inductura bears strong revolving ribs and extends far over posterior part of shell. **Miss.–Perm.** (worldwide distribution).

E. lentiformis (Weller) (**179**—27, 28). **Miss.** (Ste. Genevieve): Ill., Mo.

E. vittatus (McChesney) (**179**—29–31). **Penn.:** Widespread in central U. S. A.

E. nodocarinatus (Hall) (**179**—32, 33). **Penn.:** Widespread in central U. S. A.

CYMATOSPIRA Knight 1942

(**Bellerophon montfortianus* Norwood and Pratten). Shape as in *Bellerophon* except that aperture flares periodically, leaving transverse wavelike plicae in shell where each expansion of aperture was partly resorbed and growth resumed; selenizone narrow, occupying middle of dorsal depression; umbilici narrow; parietal inductura thickened and built up to a strongly projecting pad within aperture; ornamentation, revolving lirae which pass unbroken across transverse plicae. **Penn., Perm.** (N. America).

***C. montfortianus** N and P (**179**—34–41). **Penn.:** Mississippi Valley and Rocky Mountain region.

CARINAROPSIS Hall 1847

(= PHRAGMOSTOMA Hall 1861)

(**C. carinata*). Bellerophontid shells with a large, rapidly expanding body whorl and a small involute coil overhanging posterior margin; inner lip reflected back on spire and extended forward partly across aperture; sinus in anterior lip culminating in a short slit that generates a selenizone; ornamentation, growth lines alone. **Ord.** (widespread).

***C. carinata** Hall (**180**—1, 2). Selenizone narrow, keeled. **Ord.** (Trenton): N. Y.

C. cymbula Hall (**180**—3–5). Selenizone broad, flat. **Ord.** (Trenton): Ky., Tenn.

PTEROTHECA Salter 1853

(= CLIODERMA Hall 1861; CYCLOTHECA Teichert 1935)

(**Atrypa transversa* Portlock). Flat, explanate bellerophontid shells with a vestigial spire forming merely a small pointed, hooklike projection at posterior margin; a flat, triangular platform within aperture formed by inner lip covers visceral chamber and reminds strongly of the analogous structure in *Crepidula*; the platform supported at its apical end by pair of short lamellae; a narrow sinus in anterior lip culminates at a median dorsal crest in a short narrow slit that generates an obscure selenizone. **Ord., Sil.** (widespread).

P. saffordi (Hall) (**180**—17, 18). **Ord.** (Lebanon): Tenn.

P. expansa (Emmons) (**180**—15, 16). **Ord.** (Black River): N. Y., Mississippi Valley.

SCHIZOPEA Butts 1926

(= RHACHOPEA Ulrich and Bridge 1931)

(**S. washburnei*). Low-spired shells with rounded whorls, wide umbilicus, and with a narrow, deep, V-shaped sinus in outer lip that culminates at

PLATE 180

[Figures are x1 and original by Knight unless otherwise indicated.]

1–5. Carinaropsis spp. **1, 2. C. carinata** (x2). Side view of a crushed specimen; dorsal view of holotype. **3–5. C. cymbula.** Dorsal view of holotype (x2); view inside broken specimen (x4); apertural view of inner lip (x4). **6. Roubidouxia umbilicata** [GSA, B 43; print furnished by J. Bridge]. Side view of partly restored specimen. **7. Roubidouxia depressa.** Oblique view. **8–10. Sinuopea** spp. [8, 9: Mo G S, B 24; prints furnished by J. Bridge]. **8. S. vera. 9. S. regalis. 10. S. sweeti** (x2). **11. Schizopea washburnei.** Oblique view of holotype. **12–14. Schizopea typica.** Oblique basal view of squeeze from a paratype; squeeze from another paratype; side view of holotype showing sinus in lip. **15, 16. Pterotheca expansa** [Am Mid Nat 18]. Specimens showing two modes of preservation. **17, 18. Pterotheca saffordi.** Dorsal and ventral views (x2) of holotype of *Clioderma*.

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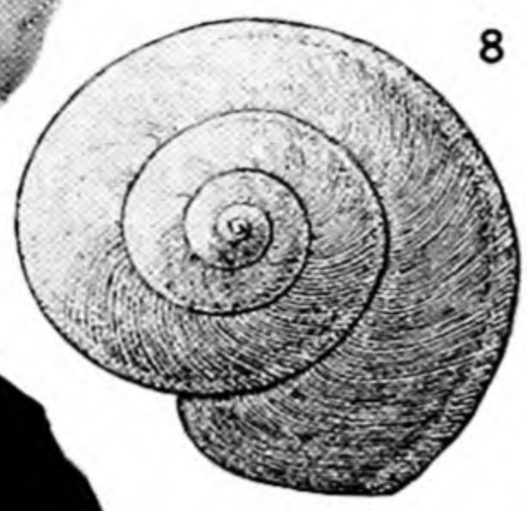

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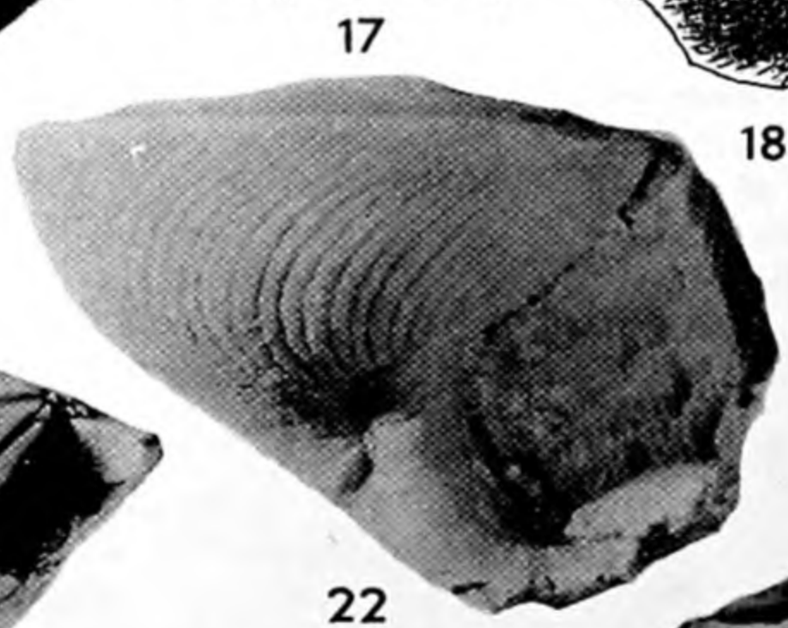

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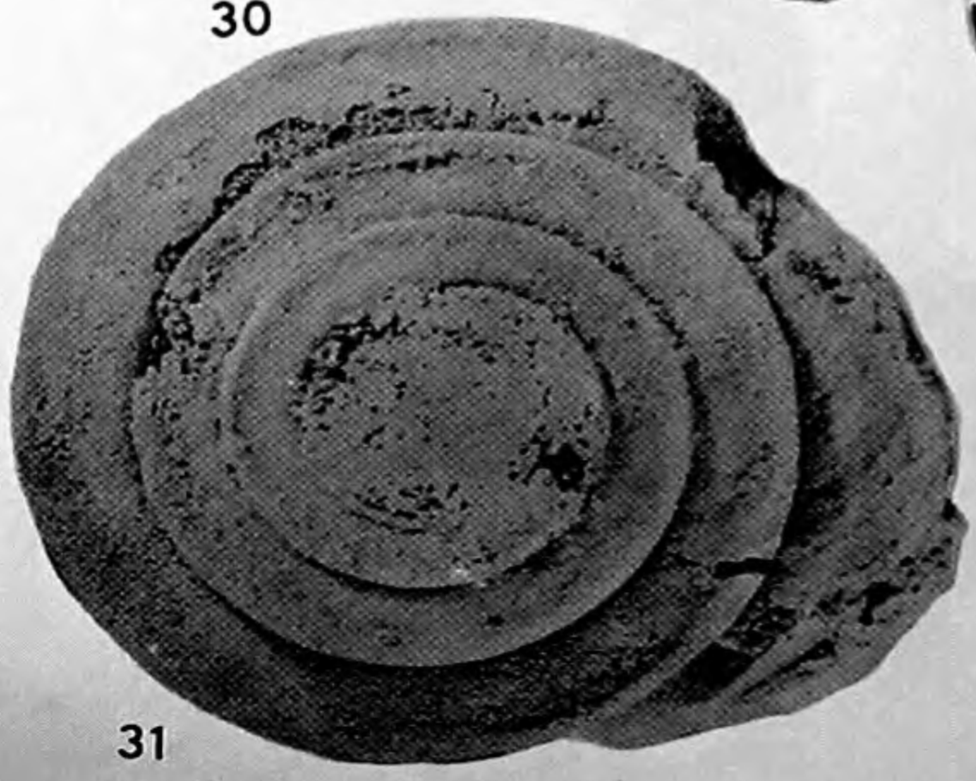

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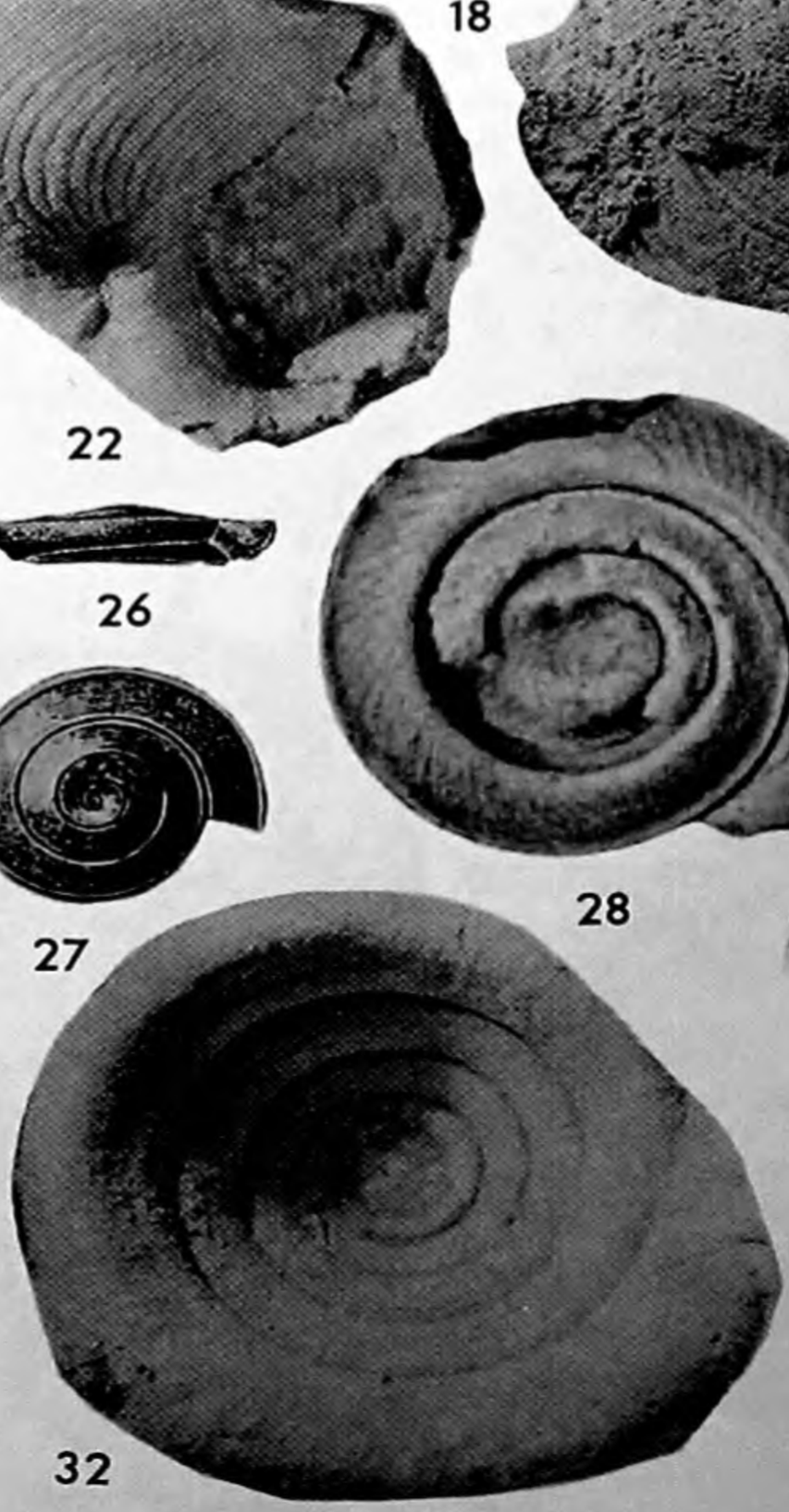

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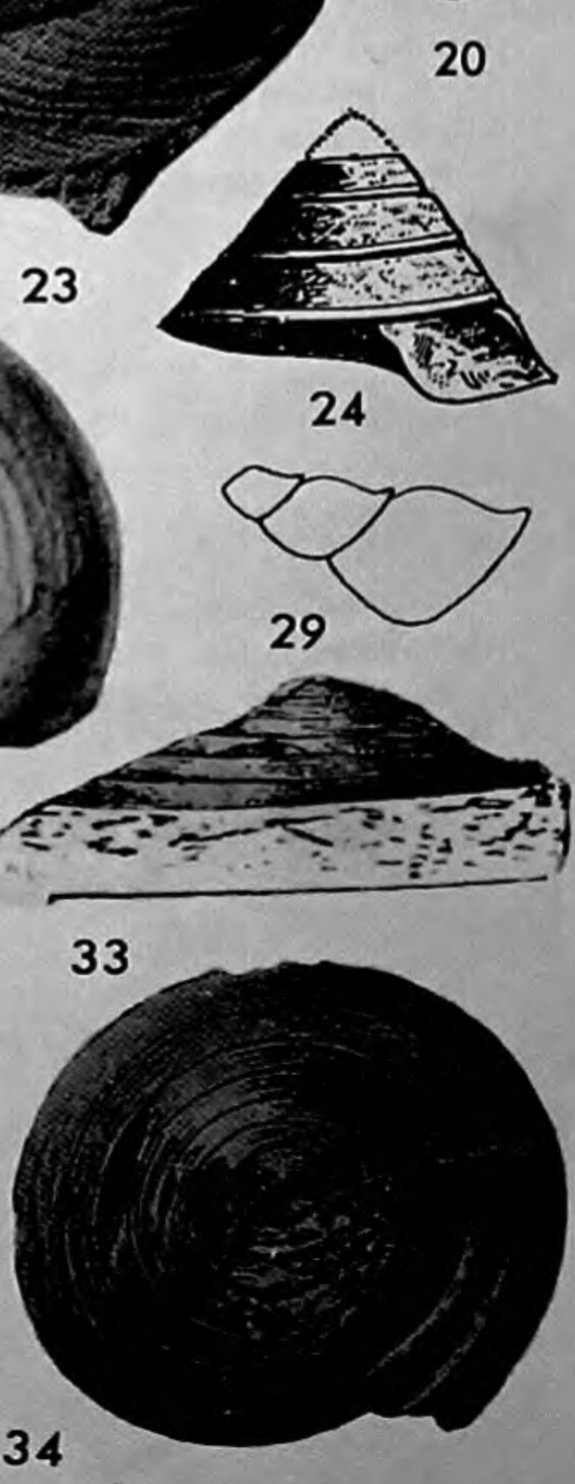

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bluntly angular periphery; ornamentation, growth lines alone. **L. Ord.** (U. S. A.).

***S. washburnei** Butts (**180**—11). **L. Ord.** (Chepultepec): Eastern U. S. A.

S. typica (Ulrich and Bridge) (**180**—12–14). **L. Ord.:** Widespread in eastern, central, and southwestern U. S. A.

SINUOPEA Ulrich 1911

(**Holopea sweeti* Whitfield). Turbinate shells with round whorls, deep sutures, and a deep sinus in outer lip; without notch, slit, or selenizone; base rounded with a small umbilicus or none; ornamentation, growth lines alone. **U. Camb., L. Ord.** (N. America).

***S. sweeti** (Whitfield) (**180**–-10). **U. Camb.** (Norwalk): U. Mississippi Valley.

S. vera Ulrich and Bridge (**180**—8). **U. Camb.** (Eminence): Central and southwestern U. S. A.

S. regalis Butts (**180**—9). **L. Ord.:** Widespread in U. S. A.

ROUBIDOUXIA Butts 1926

(**R. depressa*). Low-spired, conical shells with peripheral carina, wide umbilicus, and deep V-shaped sinus in outer lip that culminates at peripheral carina; a shallow groove just above carina in otherwise gently arched upper surface of whorls; ornamentation, growth lines alone. **L. Ord.** (N. America).

***R. depressa** Butts (**180**—7). **L. Ord.** (U. Knox): Southeastern U. S. A.

R. umbilicata Dake and Bridge (**180**—6). **L. Ord.:** Canada; eastern, central, and southwestern U. S. A.

RAPHISTOMINA Ulrich and Scofield 1897

(= ROTELLOMPHALUS Perner 1903)

(**Raphistoma lapicida* Salter). Lenticular shells without sinus, slit, or selenizone; periphery acutely subangular, often with a flattened or concave band just above it; base rounded, umbilicate; ornamentation, growth lines alone. **Ord., Sil.** (widespread).

***R. lapicida** (Salter) (**181**—1, 2). **Ord.** (Black River): Canada; Mississippi Valley.

R. affinis (Foerste) (**181**—3, 4). **Sil.** (Clinton): Mississippi Valley.

CERATOPEA Ulrich 1911

(**C. keithi*). Shell entirely unknown; genus based on opercula, which are horn-shaped with depression in base for muscle attachment; surface bearing concentric growth lines; originally thought to be an opercuium of a macluric shell but now known to belong to another group. **Ord.** (upper part of Canadian).

The genus is restricted to the upper half of the beds commonly classed as Beekmantown, or upper half of L. Ord. below the Chazy. There are at least six distinct horizons of Ceratopeas above the *Lecanospira* zone and below the Chazy. Species are known from Newf. to W. Tex., but are unknown in the Rocky Mountain region. Representatives of the genus are also known from the Northwest Highlands of Scotland (U. Durness).[1]

***C. keithi** Ulrich (**181**—5–10). **Ord.** (U. Canadian): Tenn., Ark., Mo., Arbuckle and Wichita Mountains; W. Tex.

C. tennesseensis Oder (**181**—14–16). **Ord.** (U. Canadian): S. Appalachians (U. Knox), Mo. and Ark. (Cotter), ?Wis. (Shakopee), ?W. Tex. (El Paso).

C. capuliformis Oder (**181**—11–13). **Ord.** (U. Canadian): S. Appalachians (U. Knox), Mo. and Ark. (Jefferson City), Okla. (Arbuckle and Wichita Mountains), Tex. (U. Ellenberger).

GASTROPOD OPERCULA

Fossil gastropod opercula have been reported by numerous investigators: Salter (1859, 8), Billings (1861, 243), Whiteaves (1891, 404–407), Kindle and Breger (1904), Bassler (1909), Ulrich (1911, 665), Woodring (1926, 109–111; 1926*a*, 12–14; 1936, 413), Oder (1932, 133–152), and Knight (1933, 56; 1941). In the foregoing discussion reference was made to an unpublished monograph on one common and valuable fossil operculum — *Ceratopea*. Other fossil opercula may well become important index fossils, once they are described and illustrated.

OPHILETA Vanuxem 1842

(= POLYGYRATA Weller 1906;
OZARKISPIRA Walcott 1934)

(**O. complanata*). Conical to low-conical shells with many narrow and deep whorls which are flattened above the acutely subangular periphery; a narrow, V-shaped sinus in the outer lip culminates just above

[1] Grateful acknowledgments are hereby made to Drs. E. O. Ulrich and J. Bridge, who allowed the authors to use their manuscript of an uncompleted monograph on *Ceratopea*, and who also furnished additional range and distribution data.

PLATE 181

[Figures are x1 and original by Knight unless otherwise indicated.]

1–4. Raphistomina spp. **1, 2. R. lapicida.** Oblique apical and basal views of holotype (x4). **3, 4. R. affinis** [Ohio G S 7]. Apertural view; top view enlarged (x2). **5–16. Ceratopea** spp. [All figures are of original prints furnished by E. O. Ulrich and J. Bridge. The orientation here used is that suggested by the foregoing investigators who have studied these fossils intensively.] **5–10. C. keithi.** 5-7: Lateral, ventral and dorsal views of a well preserved hypotype; 8–10: Lateral, ventral, and dorsal views of holotype. **11–13. C. capuliformis.** Lateral, ventral, and dorsal views. **14–16. C. tennesseensis.** Lateral, ventral, and dorsal views. **17–20. Raphistoma peracutum** [Minn G S 3 (2)]. Small portion of outer whorl enlarged (x5); umbilical view of a specimen (x2); apertural view of preceding (x2); outline of a specimen showing some surface markings. **21–23. Raphistoma striatum** (x2). Apical, apertural, and apical views. **24. Euconia etna** [NAIF]. **25–34. Ophileta** spp. **25. O. rotuliformis.** Side view of holotype of *Ozarkispira leo* (x6). **26, 27. O. levata** [Md G S, Camb and Ord]. Apertural and apical views of a somewhat enlarged specimen. **28, 29. O. grandis** [Mo G S, B 24]. Apical view of a broken specimen, and diagrammatic cross section of a whorl. **30–32. O. complanata.** Side, basal, and apical views (x2). **33, 34. O. hunterensis** [Md G S, Camb and Ord]. Side and apical views of type.

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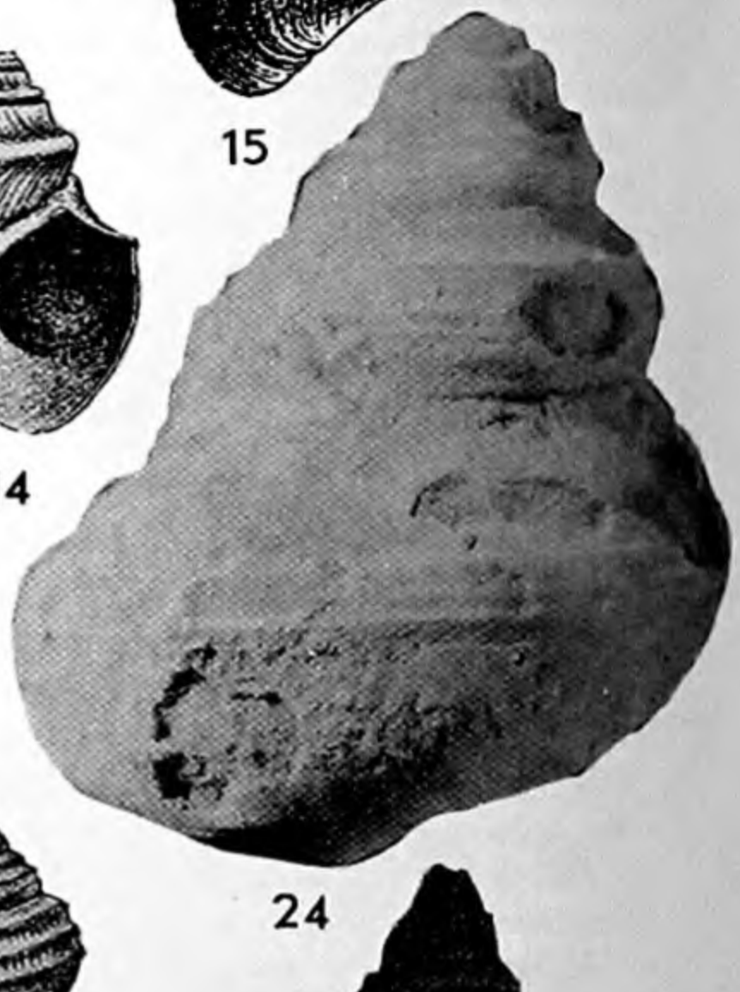
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periphery in a short, notchlike slit that generates an obscure, narrow selenizone; base with wide conical umbilicus; ornamentation, growth lines and sometimes revolving lirae. **L. Ord.** (widespread in N. America).

***O. complanata** Vanuxem (**181**—30–32). **L. Ord.** (Canadian): Widespread throughout U. S. A.

O. hunterensis (Cleland) (**181**—33, 34). **L. Ord.** (Tribes Hill): Eastern U. S. A.

O. levata (Vanuxem) (**181**—26, 27). **L. Ord.** (Tribes Hill and equivalents): Widespread throughout U. S. A.

O. rotuliformis (Meek) (**181**—25). **L. Ord.:** Western N. America.

O.? grandis (Butts) (**181**—28, 29). **L. Ord.** (Chepultepec, Gasconade): Eastern, central, and southwestern U. S. A.

RAPHISTOMA Hall 1847

(**Maclurea striatus* Emmons). Lenticular shells with a deep V-shaped sinus in outer lip culminating just above acutely subangular periphery in short notchlike slit that generates selenizone; upper surface of shell rather flat, base rounded and umbilicate; columellar lip thickened, reflexed; ornamentation, transverse growth lines or lirae which on upper surface curve strongly backward from upper suture to a line where they abruptly change direction. **Ord.** (widespread).

***R. striatum** (Emmons) (= **R. stamineum** Hall) (**181**—21–23). **Ord.** (Chazyan): Eastern and central N. America.

R. peracutum Ulrich and Scofield (**181**—17–20). **M. Ord.:** Widespread in eastern and central U. S. A.

EUCONIA Ulrich and Scofield 1897

(**Pleurotomaria etna* Billings). Conical shells with a deep sinus in outer lip culminating just above periphery in a short slit that generates selenizone; base flat, with a rather wide umbilicus; sutures linear. **L. Ord.** (Canadian) (N. America).

***E. etna** (Billings) (**181**—24). **L. Ord.:** Newf.

LOXOPLOCUS Fischer 1885

(**Murchisonia tropidophora* Whiteaves = *M. soluta* Whiteaves). Turbinate to high spired shells with sinus in outer lip that culminates at an angular periphery in a short, notchlike slit that generates a more or less obscure, convex selenizone; whorls always more or less sharply carinate with selenizone at crest of peripheral carina, in many species with one or more revolving angulations above and below peripheral carina; the later whorls may be out of contact and in some species all of them are; base with or without a small umbilicus; columellar lip thickened and flaring; ornamentation, chiefly growth lines but some species have faint revolving lirae. **Ord., Sil.** (widespread).

This genus contains many species, especially in the Ord., and it seems convenient to arrange them in the following artificial and intergrading groups, which are treated as subgenera.

LOPHOSPIRA Whitfield 1886 [= PTYCHONEMA Perner 1903; CORONILLA Perner 1907; RUEDEMANNIA Foerste 1914]. (**Murchisonia bicincta* Hall, not McCoy, = *M. milleri* Miller). Relatively low spired, turbinate forms, the last whorl sometimes out of contact.

DONALDIELLA Cossmann 1903 [= GONIOSPIRA Donald 1902; PAGODISPIRA Grabau 1914]. (**Goniospira filosa* Donald). Relatively high spired forms with the whorls for the most part in contact.

LOXOPLOCUS *ss.* Relatively high spired, corkscrewlike forms with all or most of the whorls out of contact.

L. (Lophospira) rectistriatus (Raymond) (**182**—6, 7). **Ord.** (Chazy): Eastern N. America.

L. (Lophospira) perangulatus (Hall) (**182**—3–5). **Ord.** (Chazy, Black River): Eastern and central N. America.

L. (*Lophospira) milleri (Miller) (**182**—1, 2). **Ord.** (Trenton): Eastern N. America.

L. (Loxoplocus) wisconsinensis (Ulrich and Scofield) (**182**—8, 9). **Ord.** (Black River): Mississippi Valley.

L. (Lophospira) oweni (Ulrich and Scofield) (**182**—10, 11). **Ord.** (Black River): Eastern and central U. S.A.

L. (Lophospira) serrulatus (Salter) (**182**—12, 13). **Ord.** (Black River, Trenton): Eastern and central N. America.

L. (Lophospira) sumnerensis (Safford) (**182**—14, 15). **Ord.** (Trenton): Mississippi Valley.

L. (Lophospira) liratus (Ulrich and Scofield) (**182**—24). **Ord.:** U. Mississippi Valley.

L. (Donaldiella) bowdeni (Safford) (**182**—20–22). **M.** and **U. Ord.:** Mississippi Valley.

PLATE 182

[Figures are x1 unless otherwise indicated; drawings from Minn G S 3 (2) and photographs original by Knight unless otherwise indicated.]

1–27. Loxoplocus spp. 1, 2. L. (Lophospira) milleri. Side and dorsal views of holotype (x2). **3–5. L. (Lophospira) perangulatus.** Basal view of a small shell; apertural view; dorsal view of a very large shell with last whorl free. **6, 7. L. (Lophospira) rectistriatus** (x2) [Carnegie Mus, An 4]. Portion of last whorl showing surface markings, side view. **8, 9. L. (Loxoplocus) wisconsinensis.** Two views of an internal filling. **10, 11. L. (Lophospira) oweni.** Side and apertural views. **12, 13. L. (Lophospira) serrulatus.** A typical internal filling; side view of a squeeze from an external impression. **14, 15. L. (Lophospira) sumnerensis.** Views of type. **16–19. L. (Lophospira) medialis.** Side view of a large specimen; apertural views of two incomplete shells; part of last whorl showing surface markings (x2). **20–22. L. (Donaldiella) bowdeni.** Apertural view of a high spired shell; apertural portion and side view of another shell. **23. L. (Lophospira) acuminatus. 24. L. (Lophospira) liratus.** Side view (x4). **25–27. L. (Loxoplocus) solutus.** View of spire; the holotype, final whorl showing aperture; portion of a spire. **28. Ulrichospira notabilis.** Side view of holotype (x2). **29–38. Trochonema spp. 29, 30. T. (Gyronema) historicum** [Carnegie Mus, An 4]. Views of two specimens. **31. T. (Eunema) strigillatum.** Apertural view of holotype (x2). **32. T. (Trochonemopsis) tricarinatum.** Apertural view of holotype (x2). **33. T. (Trochonema) umbilicatum.** Apertural view of a hypotype (x2). **34. T. (Gyronema) pulchellum.** Apertural view of holotype (x6). **35, 36. T. (Eunema) nitidium. 37. T. (Eunema) fatuum** [N Y St Mus, An Rp 20]. **38, 39. T. (Trochonema) beloitense.** Two views of a large specimen.

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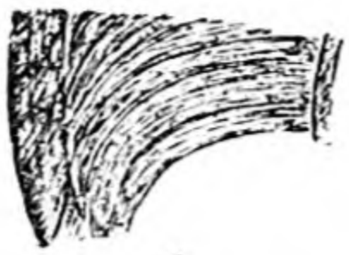
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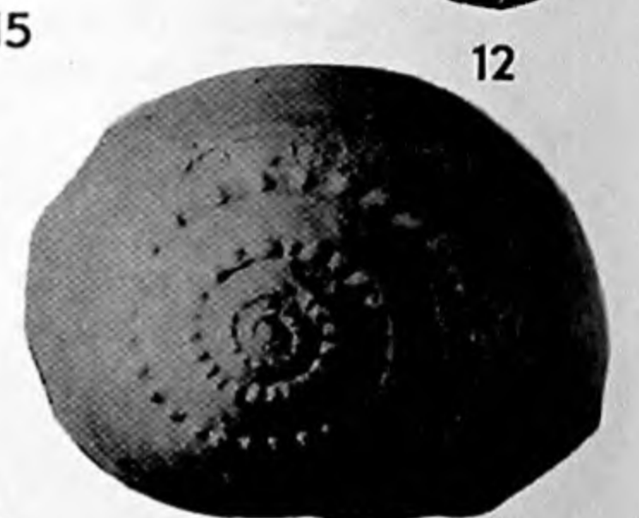
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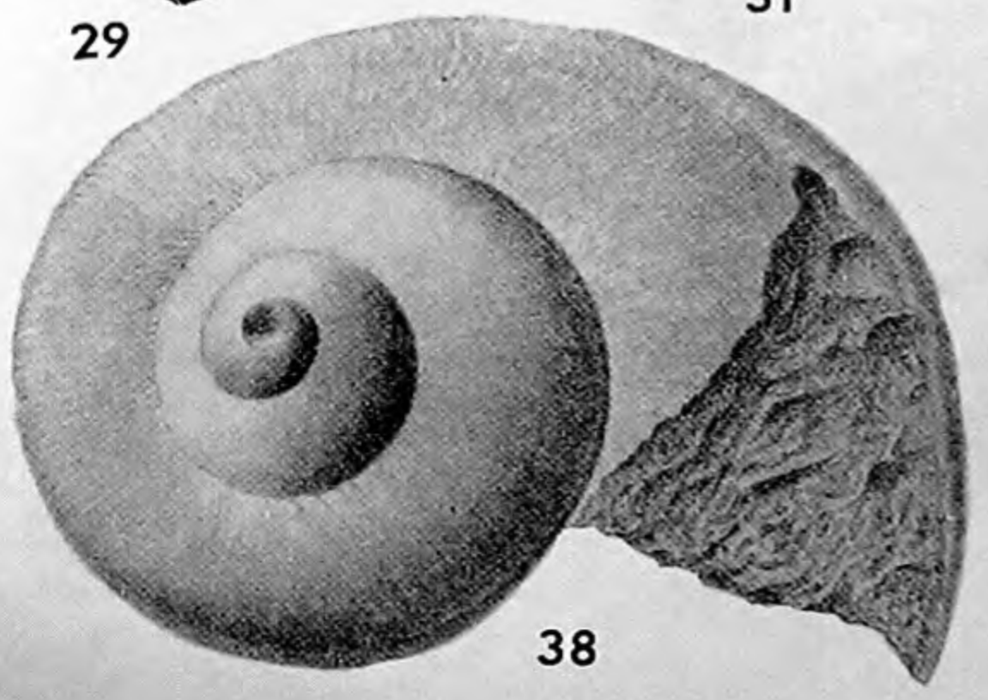
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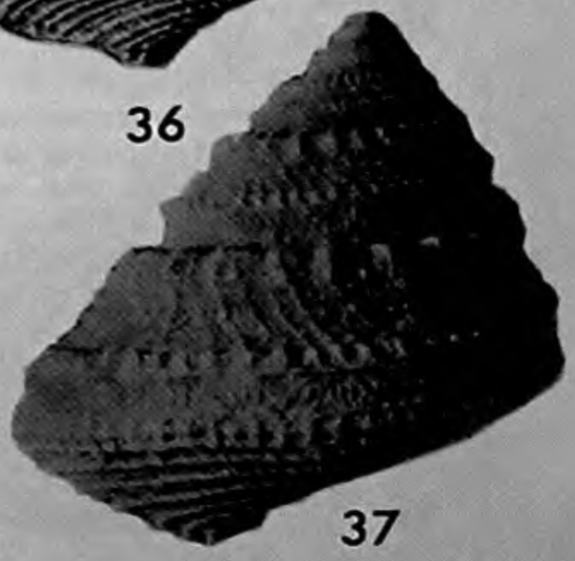
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L. (Lophospira) medialis (Ulrich and Scofield) (182—16–19). **M.** and **U. Ord.:** Eastern, central, and southwestern U. S. A.

L. (Lophospira) acuminatus (Ulrich and Scofield) (182—23). **Ord.** (Richmond): Mississippi Valley.

L. (*Loxoplocus) solutus (Whiteaves) (182—25–27). **Sil.** (Niagaran): Canada.

ULRICHOSPIRA Donald 1905
(= TROCHONEMELLA Okulitch 1935)

(**U. similis*). Turbinate shells with a narrow, shallow sinus in outer lip that culminates at periphery in a short, notchlike slit which generates a well marked selenizone; whorls with well marked angulations above and below selenizone and a slight emargination at each angulation; base with or without a small umbilicus; ornamentation, rather strong and foliaceous or varixlike growth lamellae, often particularly conspicuous where they form lunulae of selenizone. **Ord., Sil.** (widespread).

U. notabilis (Ulrich and Scofield) (182—28). **M. Ord.:** Tenn.

TROCHONEMA Salter 1859

(**Pleurotomaria umbilicata* Hall). High to low spired, turbinate shells with at least two carinate revolving angulations about the whorls; commonly two additional carinae, one near upper suture and another around umbilicus; in some species there are additional intercalated carinae or costae; final whorl in old shells often out of contact; outer lip more or less oblique, often with a broad and shallow sinus culminating at upper of the two principal carinae; the upper carina commonly channeled within at aperture; columellar lip thin, not excavated; umbilicus fairly wide to minute; except where intercalated, revolving costae are developed; ornamentation consists of growth lines alone which in some species are fasciculate or lamellose. **Ord.–Dev.** (widespread).

This genus contains many species, especially in the Ord., and it seems convenient to arrange them in the following artificial and intergrading groups, which are treated as subgenera.

TROCHONEMA *ss*. The two principal angulations well developed; spire low; umbilicus rather wide. **Ord.**

EUNEMA Salter 1859 (**E. strigillatum*). The two principal angulations well developed; spire high; umbilicus minute. **Ord., Sil.**

GYRONEMA Ulrich and Scofield 1897 (**G. pulchellum*). Rather numerous costae intercalated between principal ones; umbilicus narrow. **Ord., Sil.**

TROCHONEMOPSIS Meek 1872 (**Trochonema tricarinata*). Lower of two principal angulations prominent and forming an angular periphery; umbilicus narrow. **Dev.**

T. (Gyronema) historicum (Hudson) (182—29, 30). **Ord.** (Chazyan): Eastern N. America.

***T. (Trochonema) umbilicatum** (Hall) (182—33). **Ord.** (Black River, Trenton): Widespread in N. America.

T. (Trochonema) beloitense Whitfield (182—38, 39). **Ord.** (Black River): Mississippi Valley.

T. (*Eunema) strigillatum (Salter) (182—31). **Ord.** (Black River): Canada.

T. (*Gyronema) pulchellum Ulrich and Scofield (182—34). **Ord.** (Black River): Canada.

T. (Eunema) nitidium Ulrich and Scofield (182—35, 36). **Ord.** (Eden): Mississippi Valley.

T. (Eunema) fatuum (Hall) (182—37). **Sil.** (Niagaran): Mississippi Valley.

T. (*Trochonemopsis) tricarinatum (Meek) (182—32). **Dev.** (Onondaga): Mississippi Valley.

YUNNANIA Mansuy 1912
(= PORTLOCKIA Koninck 1881)

(**Y. termieri*). Turbinate shells which have a shallow, V-shaped sinus in outer lip, but without slit or selenizone; base rounded, with or without a minute umbilicus; ornamentation, conspicuous revolving carinae or costae with relatively broad, rounded interspaces and fine growth lines, the latter in some species fasciculated close to upper suture. **Miss.–Perm.** (widespread).

Y. leavenworthana (Hall) (183—7). **Miss.** (Salem): Mississippi Valley.

Y. subsinuata (Meek and Worthen) (183—8). **Penn.** (Des Moines): Misssissippi Valley.

LIOSPIRA Ulrich and Scofield 1897
(= EOCRYPTAENIA Koken 1925)

(**Pleurotomaria micula* Hall). Lenticular shells with deep sinus culminating at acutely subangular periphery in shallow slit that generates a convex selenizone; selenizone forms periphery and extends farther on upper side than on lower; base gently arched with an umbilicus partly or wholly filled with callus; columellar lip thickened and reflexed above umbilicus; ornamentation, growth lines alone. **Ord.** (widespread).

PLATE 183

[Figures are x1 unless otherwise indicated; JBK = original by J. B. Knight.]

1–6. Liospira micula. 1, 2: Oblique upper and lower views (x4) [JBK]. 3–6: Three views of a large specimen, and portion of upper side of last whorl enlarged (x5) [Minn G S 3 (2)]. **7, 8. Yunnania** spp. **7. Y. leavenworthana** [AMNH, B 1 (3)]. **8. Y. subsinuata** [JBK]. Side view (x5). **9–15. Liospira** spp. [Minn G S 3 (2)]. **9–12. L. vitruvia.** Vertical section, and three views of an internal filling. **13–15. L. progne.** Basal view, vertical section, and profile view of three specimens. **16–23. Trepospira** spp. **16–18. T. rotalia** (x4) [Pal N Y 5 (2)]. Side and top views of a specimen; basal view of a second specimen. **19, 20. T. sphaerulata** [JBK]. Side and apertural views (x2). **21–23. T. discoidalis** [JP 9]. Three views of holotype. **24–27. Phanerotrema** spp. **24–26. P. labrosum** [Pal N Y 3]. Portion of surface enlarged; two views of an imperfect specimen (x0.8). **27. P. occidens** [NAIF]. **28. Euryzone rugulata** (x2) [Pal N Y 5 (2)]. **29–31. Rhineoderma** spp. [Ind G S 30]. **29. R. wortheni.** Apertural view of type. **30, 31. R. piasaense.** Apertural and top views (x3). **32, 33. Gosseletina** spp. (x2). **32. G. subglobosa** [Ind G S 30]. **33. G. spironema** [JBK]. Side view. **34. Borestes pagoda** [JP 9]. Holotype (x4). **35–37. Phymatopleura** spp. **35, 36. P. brazoensis** [Wash Ac Sc, J 29]. **37. P. nodosus** [JBK]. Side view (x5). **38, 39. Euryzone arata** [Pal N Y 5 (2)]. Views of two obliquely compressed specimens.

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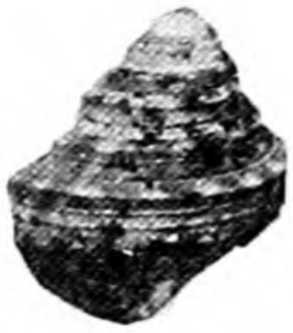
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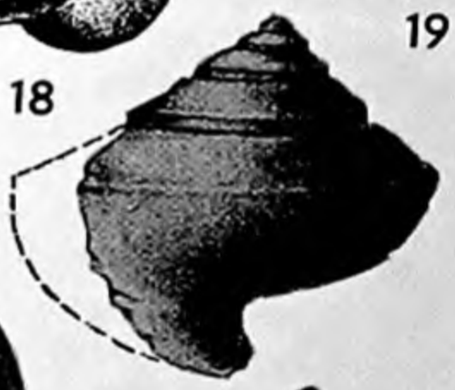
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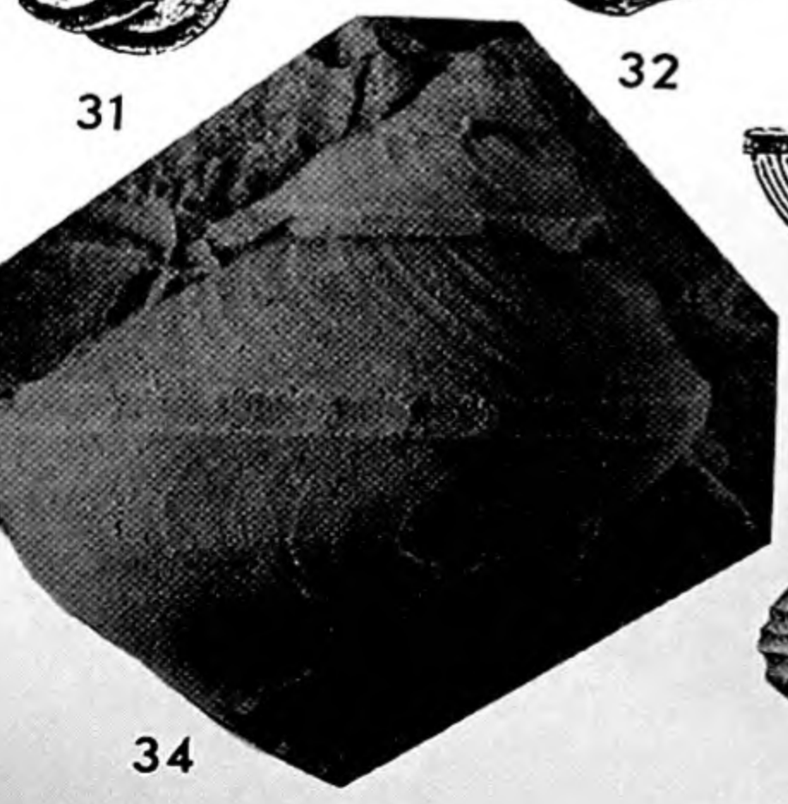
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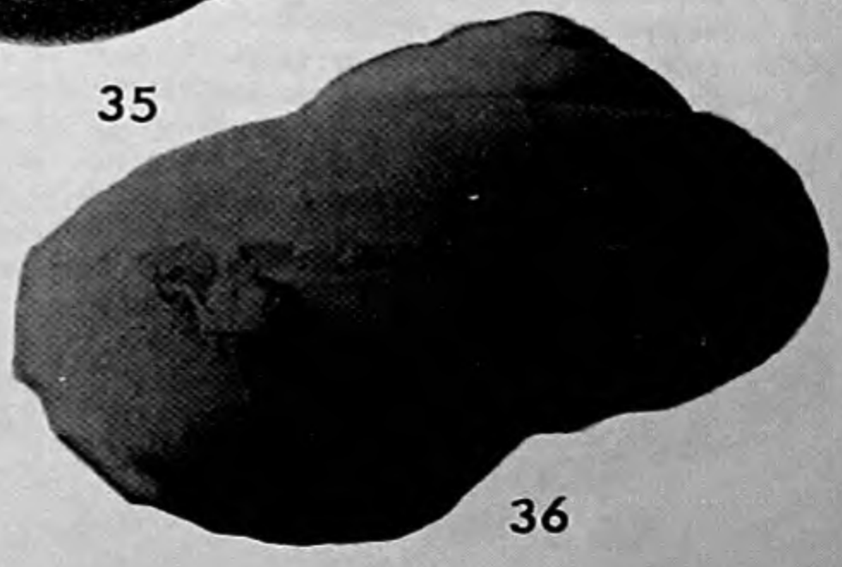
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***L. micula** (Hall) (**183**—1–6). **Ord.** (Trenton–Richmond): Eastern and central U. S. A.

L. progne (Billings) (**183**—13–15). **Ord.** (Stones River–Trenton): Canada: Mississippi Valley.

L. vitruvia (Billings) (**183**—9–12). **Ord.** (Black River–Richmond): Eastern Canada and U. S. A.; Mississippi Valley.

L. americanum (Billings). Differs from preceding in having more rounded lower lip, as shown by growth lines, and wider and less abrupt umbilicus without angulation. **Ord.** (Stones River–Richmond): Widespread throughout N. America.

TREPOSPIRA Ulrich and Scofield 1897
(= ANGYOMPHALUS Cossman 1915)

(**Pleurotomaria sphaerulata* Conrad). Conical to lenticular shells with a shallow sinus in outer lip culminating just above subangular periphery in a shallow slit that generates a flat selenizone flush with upper whorl face; base flatly arched, with umbilicus wholly or partly filled with a callus; ornamentation, other than very fine growth lines, usually a conspicuous row of nodes just below upper suture. **Dev.–Penn.**

T. rotalia (Hall) (**183**—16–18). **Dev.** (Hamilton): Eastern U. S. A.

***T. sphaerulata** (Conrad) (**183**—19, 20). **Penn.** (U. Des Moines): Mississippi Valley.

T. discoidalis Newell (**183**—21–23). **Penn.** (Missouri): Mississippi Valley.

PHANEROTREMA Fischer 1885

(**Pleurotomaria labrosa* Hall). Turbinate shells with a shallow slit that generates a selenizone rather high on gently oblique outer lip; base subconical, without an umbilicus; inner lip thickened; ornamentation, revolving lirae and fainter transverse lirae. **Sil., L. Dev.** (widespread).

P. occidens (Hall) (**183**—27). **Sil.** (Niagaran): Mississippi Valley.

***P. labrosum** (Hall) (**183**—24–26). **L. Dev.:** Eastern U. S. A.

EURYZONE Koken 1896
(= UMBOTROPIS Perner 1903;
COELOZONE Perner 1907)

(**Helicites delphinuloides* Schlotheim). Turbinate shells with moderate sinus in outer lip culminating at or a little above periphery in a shallow slit that generates a broad, concave selenizone; base convex, with an umbilicus; ornamentation, principally transverse growth lines but sometimes very faint revolving lines as well. **Sil., Dev.** (widespread).

E. rugulata (Hall) (**183**—28). **Dev.** (Marcellus): Eastern N. America.

E. arata (Hall) (**183**—38, 39). **Dev.** (Schoharie, Onondaga): Eastern N. America.

GOSSELETINA Fischer 1885
(= GOSSELETIA Koninck 1883)

(**Pleurotomaria callosa* Koninck). Globular-turbinate shells with a shallow sinus culminating in outer lip in a short slit that generates a selenizone rather high on the deeply embracing whorls; base rounded, with narrow umbilicus sometimes completely covered by callus; ornamentation lacking, or revolving lirae on whorl face and sometimes on selenizone, and transverse lirae sometimes fasciculating into nodes, or growth lines alone. **Miss., Penn.** (widespread).

G. subglobosa (Hall) (**183**—32). **Miss.** (Salem): Mississippi Valley.

G. spironema (Meek and Worthen) (**183**—33). **Penn.** (Des Moines): Mississippi Valley.

BAYLEA Koninck 1883
(= YVANIA Fischer 1885;
HYPSELENTOMA Weller 1929)

(**Trochus yvanii* Léveillé). Turbinate to subconical shells with narrow, shallow sinus in outer lip that culminates in a shallow, notchlike slit which generates a selenizone on outer edge of shoulder just above shoulder angle; whorl profile sloping outward across shoulder to shoulder angle and downward from that angle to subangular border of base; base rounded to flatly rounded, with small umbilicus or none; ornamentation, various revolving carinae and lirae with transverse lirae or growth lines. **Miss.–Perm.** (widespread).

B. subconstricta (Meek and Worthen) (**184**—1–5). **Penn.** (U. Des Moines): Mississippi Valley.

B. knighti (Weller) (**184**—6, 7). **Penn.** (U. Des Moines): Mississippi Valley.

B. perhumerosa (Meek) (**184**—8, 9). **Penn.** (Missouri): Midcontinent region.

B. capertoni (Beede) (**184**—10–12). **Perm.** (Guadalupian): Southwestern U. S. A.

RHINEODERMA Koninck 1883

(**Pleurotomaria radula*). Turbinate shells with short

PLATE 184

[Figures are x1 and original by Knight unless otherwise indicated.]

1–12. Baylea spp. 1–5. B. subconstricta. Side views (x1, x2); three side views (x5) showing color pattern. **6, 7. B. knighti.** Side view (x5) showing color pattern; apertural view (x10). **8, 9. B. perhumerosa.** Apertural view of a paratype (x4); the holotype of *Hypselentoma* (x6), a mashed specimen with excellent growth lines. **10–12. B. capertoni** (x8). Side view; details of ornamentation; side view. **13–20. Eotomaria spp. 13, 14. E. canalifera** (x2). Oblique basal view of a paratype; side view of holotype. **15–17. E. supracingulata** [Minn G S 3 (2)]. Three views of a large specimen. **18, 19. E. dryope** [Minn G S 3 (2)]. Two views of an internal filling. **20. E. galtensis** [CGS, Pal Fos 3]. Side view of a broken specimen. **21–24. Glabrocingulum spp. 21–23. G. grayvillense** [USGS, B 544]. Basal, apical, and side views (x3). **24. G. wannense** [JP 9]. Apertural view of holotype (x2). **25–30. Bembexia spp.** [Pal N Y 5 (2)]. **25, 26. B. sulcomarginata.** Apertural and side views (x2). **27, 28. B. trilix.** Side views of two specimens (x2). **29. B. adjutor. 30. B. capillaria.** Apertural view of a specimen (x2). **31–34. Clathrospira spp. 31–33. C. conica** [Minn G S 3 (2)]. Basal and side views of a rather small specimen; portion of surface enlarged (x2). **34. C. subconica.** Side view of holotype (x2). **35. Mourlonia lucina** [Pal N Y 5 (2)]. **36. Mourlonia filitexta.** Side view of holotype of *Eocryptaulina* (x6).

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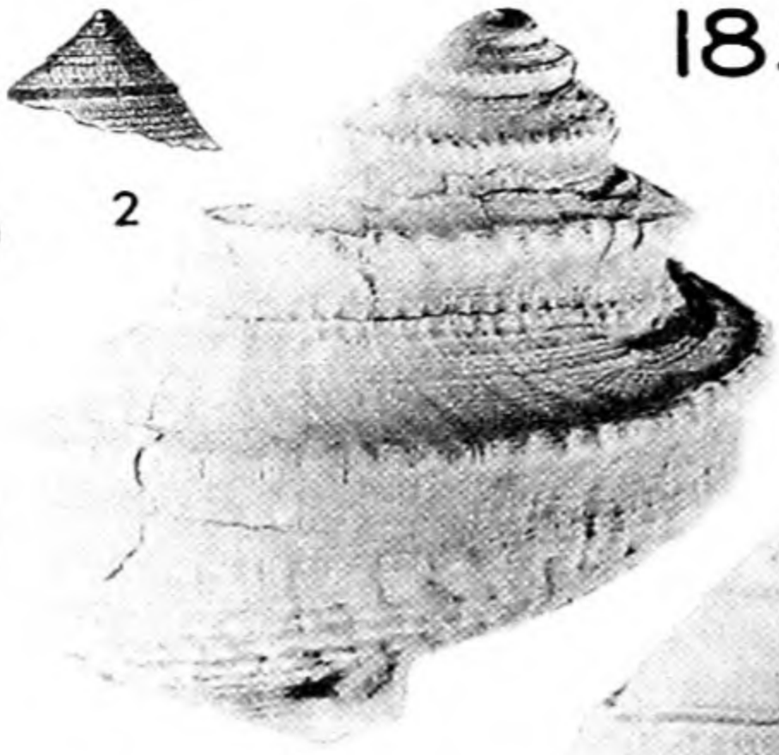

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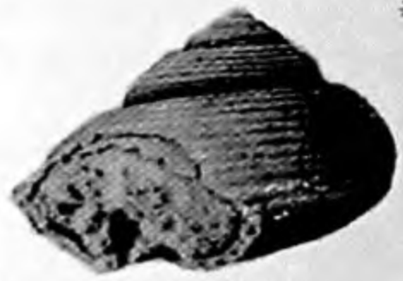

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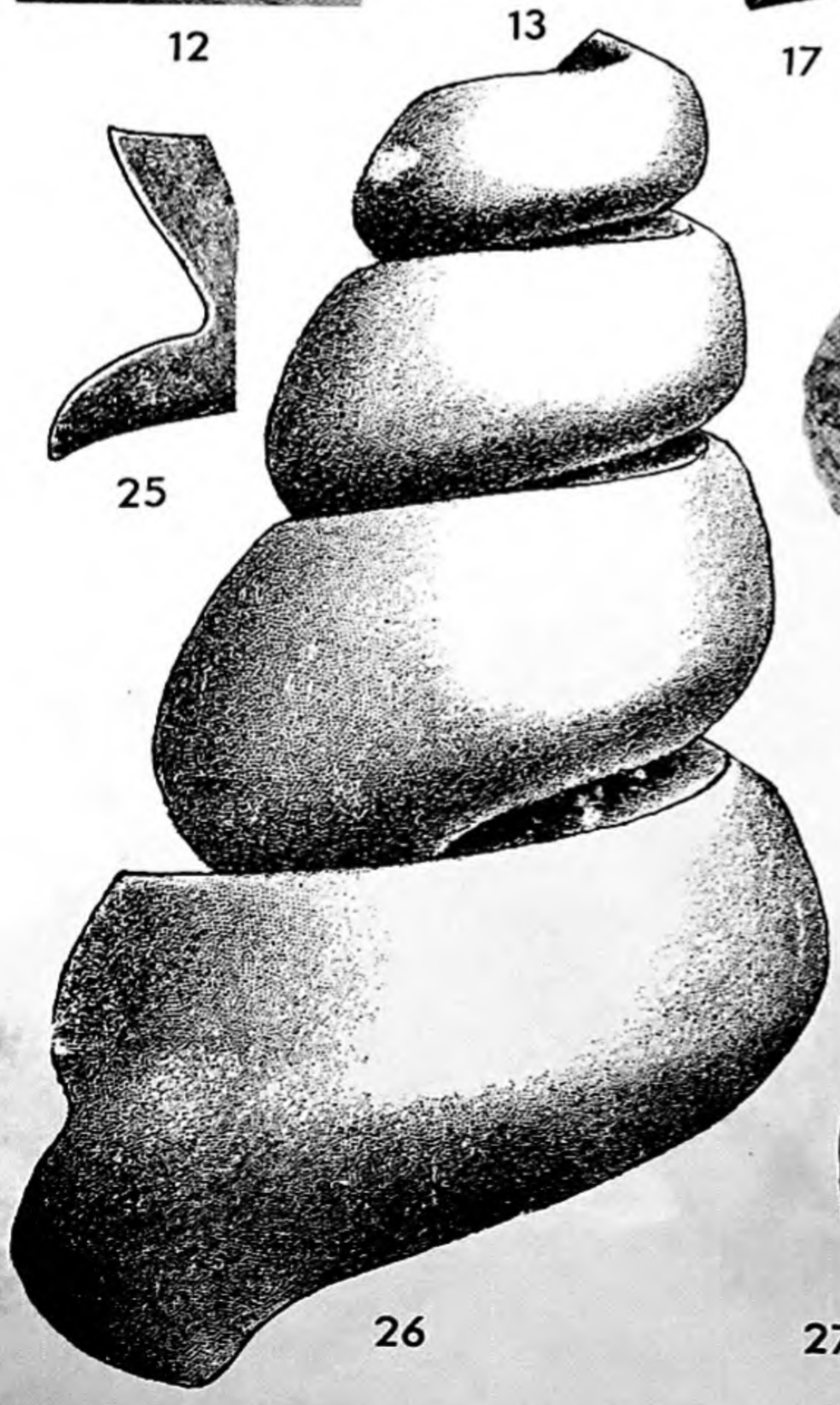

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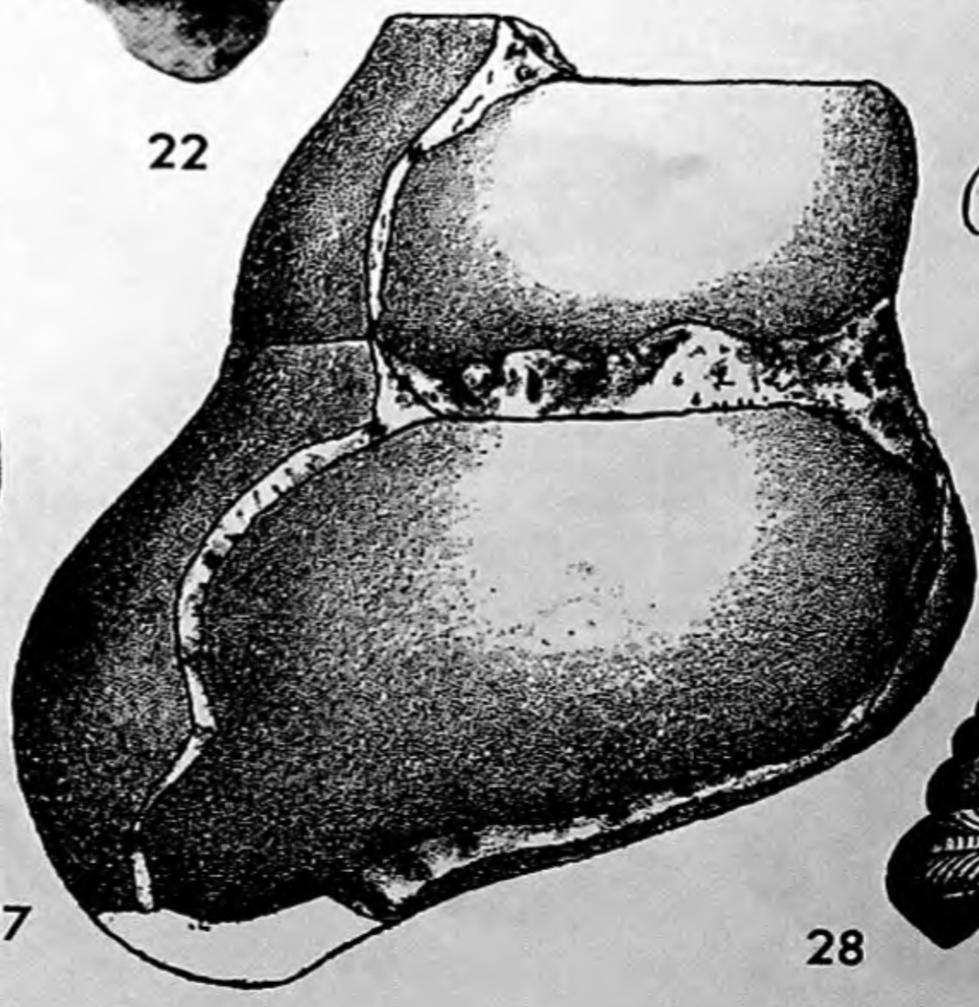

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slit in oblique outer lip that generates selenizone at broadly subangular periphery; base flatly rounded with conspicuous conical umbilicus; ornamentation, strong revolving and transverse lirae. **Miss.** (widespread).

R. wortheni (Hall) (**183**—29). **Miss.** (Salem): Mississippi Valley.

R. piasaense (Hall) (**183**—30, 31). **Miss.** (Salem): Mississippi Valley.

PHYMATOPLEURA Girty 1939

(= ORESTES Girty 1912)

(**Orestes nodosus*). Subconical shells with shallow sinus in outer lip that culminates in short slit which generates selenizone on a narrow peripheral flattened band; whorl profile sloping outward from noded shoulder just below upper suture to the nearly vertical flattened band which bears selenizone, the lower subangular margin of this band forming periphery; base flatly arched, with or without minute umbilicus; ornamentation, sharp revolving and transverse lirae and nodes. **Penn.** (widespread in U. S. A.).

***P. nodosus** (Girty) (**183**—37). **Penn.:** Central U. S. A.

P. brazoensis (Shumard) (**183**—35, 36). **Penn.:** Central U. S. A.

BORESTES Thomas 1940

(**B. wrighti*). Turreted, turbinate shells with shallow sinus in outer lip culminating in a short slit that generates selenizone on vertical, peripheral whorl face; whorl profile slopes outward from upper suture to carina and downward, usually with some concavity, from carina to a broad angulation that limits base; selenizone midway between carina and basal angulation; base flatly rounded; ornamentation, strong revolving and transverse lirae. **Miss., Penn.** (widespread).

B. pagoda (Newell) (**183**—34). **Penn.** (Missouri): Mississippi Valley.

EOTOMARIA Ulrich and Scofield 1897

(= SPIRORAPHE Perner 1907)

(**E. canalifera*). Depressed conical shells with a deep, V-shaped sinus in outer lip culminating just above angular, subcarinate periphery in a short slit that generates a well marked, flat or concave selenizone, which lies entirely above periphery; juvenile whorls rather high spired; base gently rounded with narrow umbilicus; ornamentation, other than selenizone and its often sharply raised margin, growth lines alone. **Ord., Sil.** (widespread).

***E. canalifera** U and S (**184**—13, 14). Whorls embracing to periphery; umbilicus small. **Ord.** (Stones River): Mississippi Valley.

E. supracingulata (Billings) (**184**—15–17). Whorls not embracing to periphery; umbilicus larger than in preceding. **Ord.** (Black River): Canada; Mississippi Valley.

E. dryope (Billings) (**184**—18, 19). Whorls with rounded shoulder near upper suture. **Ord.** (Black River): Canada; Mississippi Valley.

E. galtensis (Billings) (**184**—20). **Sil.** (Guelph): Eastern Canada; N. Y.

GLABROCINGULUM Thomas 1940

(**G beggi*). Turbinate shells with shallow sinus in outer lip culminating at periphery in a short slit that generates a concave selenizone lying between low carinae; whorl profile slopes outward from upper suture to selenizone and then downward roundly to base; base rounded, with small umbilicus, which is usually partly filled with a callus; ornamentation, both revolving and transverse, which often form nodes where the two elements cross. **Miss.–Perm.** (widespread).

G. grayvillense (Norwood and Pratten) (**184**—21–23). **Penn.:** Widespread throughout the U. S. A.

G. wannense (Newell) (**184**—24). **Penn.** (Missouri): Midcontinent region.

CLATHROSPIRA Ulrich and Scofield 1897

(= PALAEOSCHISMA Donald 1902)

(**Pleurotomaria subconica* Hall). Subconical, turbinate shells with rather sharply angulated whorls and a deep sinus in outer lip culminating on periphery in a shallow slit that generates a nearly vertical, slightly concave selenizone; base rounded, with a narrow umbilicus, in some species with a faint revolving ridge; ornamentation, fine growth lines crossed by fine revolving lirae. **Ord., Sil.** (widespread).

***C. subconica** (Hall) (**184**—34). **Ord.** (Black River–Richmond): Canada; eastern U. S. A., Mississippi Valley

C. conica Ulrich and Scofield (**184**—31–33). Similar to preceding except with revolving ridge on base. **Ord.** (Black River–Trenton): Mississippi Valley.

PLATE 185

[Figures are x1 unless otherwise indicated; drawings from Minn G S 3 (2) and photographs original by Knight unless otherwise indicated.]

1, 2. Mourlonia mississippiensis [Pal Ohio 2]. Side view of a complete specimen; apical portion showing ornamentation. **3. Mourlonia itys** [Pal N Y 5 (2)]. **4. Worthenia tabulata.** Side view (x2). **5–7. Worthenia speciosa** [Ill G S 2]. Apertural and side views; portion of whorl enlarged to show ornamentation. **8. Shansiella carbonaria.** Apertural view. **9, 10. Shansiella planicostata** [JP 11]. Two views of holotype (x5). **11. Euconospira turbiniformis.** Side view of holotype (x2). **12–17. Hormotoma** spp. **12, 13. H. gracilis.** The holotype (x4), a typical internal filling (x2). **14–17. H. gracilis.** Incomplete specimens showing varietal characteristics (x2). **18–20. Stegocoelia** spp. **18. S. illinoiensis** (x4) [Walker Mus (Chicago), Contr 1]. **19. S. turritella** (x2) [Ind G S 30]. **20. S. wortheni.** Side view (x3). **21. Goniasma lasallensis.** A topotype (x4). **22–29. Hormotoma** spp. **22. H. gigantea** (x0.4) [CGS, M 154]. **23, 24. H. trentonensis.** Apertural and side views of two specimens. **25–27. H. major.** Outline of outer lip showing broad sinus (x0.7); two broken internal fillings, the latter showing external nature of sutures. **28. H. bellicincta.** Side view of a specimen showing some ornamentation. **29. H. whiteavesi** [N Y St Mus, M 5].

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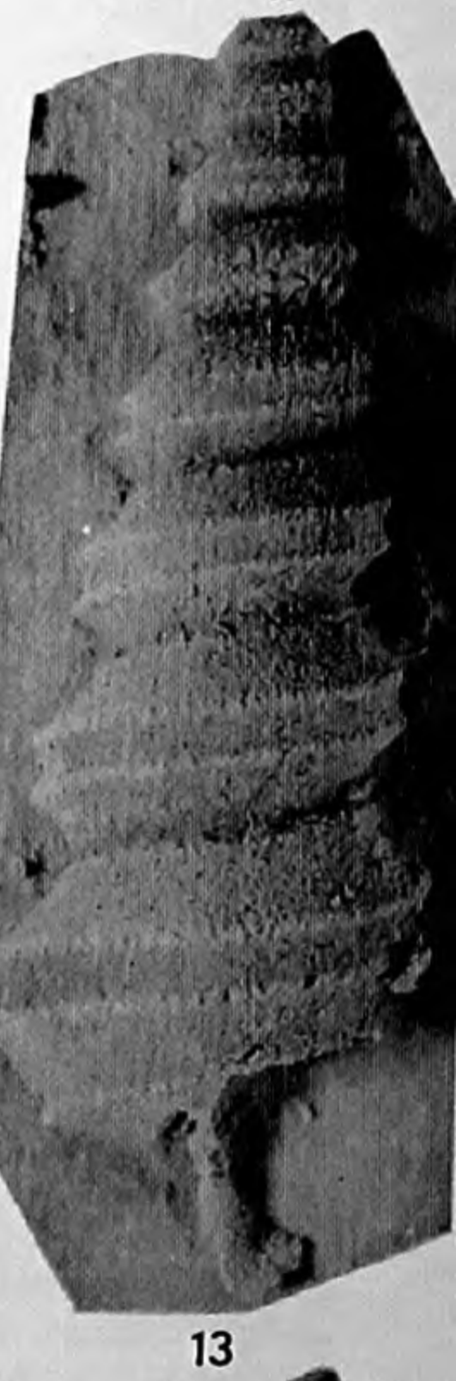
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BEMBEXIA Oehlert 1888

(**Pleurotomaria larteti* Munier-Chalmas). Turbinate shells of moderate size with subangular whorls and a concave selenizone lying between two sharp revolving carinae on periphery; umbilicus minute or wanting; usually one or two faint revolving ridges on upper whorl surface and sometimes another below selenizone; ornamentation, transverse growth lines sometimes fasciculating into nodes near upper suture and where they cross revolving ridges, and sometimes revolving lirae. **?Sil., Dev.** (widespread).

B. sulcomarginata (Conrad) (**184**—25, 26). **M. Dev.** (Hamilton): Eastern U. S. A., Mississippi Valley.

B. capillaria (Conrad) (**184**—30). **M. Dev.** (Hamilton): Eastern U. S. A.

B. trilix (Hall) (**184**—27, 28). **M. Dev.** (Hamilton): Eastern U. S. A.

B. adjutor (Hall) (**184**—29). **Dev.** (Onondaga): Eastern U. S. A., Mississippi Valley.

MOURLONIA Koninck 1883

(= PTYCHOMPHALINA Fischer 1885; PROMOURLONIA Longstaff 1924; CRYPTAULUS Foerste 1925; FOERSTERIA Tomlin 1929; EOCRYPTAULINA Foerste 1936)

(**Helix carinatus* Sowerby). Turbinate shells with shallow sinus in the rather oblique outer lip culminating at rounded periphery in a moderately deep slit which generates selenizone; whorls rounded, embracing almost to selenizone; base rounded, with or without a narrow umbilicus; ornamentation, rather strong transverse lirae, in some species crossed by fine revolving lirae. **Sil.–Perm.** (widespread).

M. filitexta (Foerste) (**184**—36). **Sil.** (Brassfield): Mississippi Valley.

M. itys (Hall) (**185**—3). **Dev.** (Hamilton): Eastern and central U. S. A.

M. lucina (Hall) (**184**—35). **Dev.** (Onondaga, Hamilton): Eastern and central U. S. A.

M. mississippiensis (White and Whitfield) (**185**—1, 2). **L. Miss.:** Mississippi Valley.

WORTHENIA Koninck 1883

(**Turbo tabulatus* Conrad). Turreted, turbinate shells with a shallow sinus in outer lip culminating at peripheral carina in a slit of moderate depth that generates selenizone; selenizone is usually convex and ornamented by nodes and revolving lirae; whorl profile slopes outward from upper suture to carina and downward usually with some concavity from the carina to a broad angulation that limits base; base gently rounded, with minute umbilicus or none at all; ornamentation, usually well developed, of both revolving and transverse elements which may combine to form nodes at various points. **Miss.–Perm., ?Trias.** (widespread).

***W. tabulata** (Conrad) (**185**—4). **Miss.:** Mississippi Valley.

W. speciosa (Meek and Worthen) (**185**—5–7). **Penn.:** Mississippi Valley.

SHANSIELLA Yin 1932

(= LATISCHISMA Thomas 1940)

(**S. altispiralis*). Globular-turbinate shells with a shallow slit in oblique outer lip that generates a selenizone rather low on whorl face; base rounded without an umbilicus; ornamentation, many strong revolving costae and finer growth lines. **Miss.–Perm.** (Widespread).

S. carbonaria (Norwood and Pratten) (**185**—8). **Penn.:** Mississippi Valley.

S. planicostata (Girty) (**185**—9, 10). **Perm.** (Abo): Southwestern U. S. A.

EUCONOSPIRA Ulrich and Scofield 1897

(= TRECHMANNIA Longstaff 1912)

(**Pleurotomaria turbiniformis* Meek and Worthen). Conical shells with deep sinus in outer lip culminating just above periphery in a deep slit which generates selenizone deeply buried between two carinae; base flat, with narrow umbilicus; sutures linear. **Miss.–Perm.** (widespread).

***E. turbiniformis** (M and W) (**185**—11). **Penn.** Mississippi Valley.

HORMOTOMA Salter 1859

(= ?CYRTOSTROPHA Donald 1902; MESOCOELIA Perner 1907; SINUSPIRA Perner 1907).

(**Murchisonia gracilis* Hall). High spired shells with many rounded whorls and a sinus in outer lip culminating in a short, notchlike slit that generates a flat or gently concave selenizone; base rounded, without an umbilicus; ornamentation, other than selenizone, growth lines alone. **Ord., Sil.** (widespread).

H. gracilens (Whitfield). **Ord.** (U. Beekmantown): Appalachians (Va. to Ala.), Wis.?, Mo. to Tex.

***H. gracilis** (Hall) (**185**—12–17). **Ord.** (Trenton–Richmond): Widely distributed in Canada and U. S. A.

PLATE 186

[Figures are x1 unless otherwise indicated; drawings from Pal N Y 5 (2) and photographs original by Knight unless otherwise indicated.]

1–8. Murchisonia spp. 1, 2. M. desiderata. Apertural view and portion of surface enlarged. **3. M. vincta** [Ind G S 30]. Apertural view of one of the type specimens (x2). **4, 5. M. maia** (x2). The holotype and another specimen. **6–8. M. gouldii.** Specimens showing very low (x4), low (x4), and high (x6) selenizones. **9–11. Gasconadia putilla.** Basal and side views of holotype, a chert filling (x6); apertural view of an unusually perfect specimen. **12, 13. Ectomaria pagoda** (x4). Fragment showing growth lines; apertural view. **14. Ectomaria prisca** [Minn G S 3 (2)]. **15–22. Loxonema spp. 15. L. leda** [N Y St Mus, An Rp 20]. **16. L. hamiltoniae.** A typical specimen. **17, 18. L. delphicola.** Views of two specimens. **19, 20. L. noe** [N Y St Mus, M 6]. A small shell with smooth whorls (x13); a mature shell (x3). **21. L. terebra. 22. L. murrayanum** [CGS, COR d 1]. Apertural view of an imperfect specimen. **23–25. Coelocaulus macrospira** [N Y St Mus, M 5]. A complete specimen; last whorls showing surface markings; axial section showing outlines of whorls. **26. Eoptychia trochus.** Side view (x4). **27. Eoptychia rothi.** Side view (x8). **28, 29. Microptychis crenimarginatus.** Apertural view (x10) and dorsal view (x8).

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H. trentonensis Ulrich and Scofield (**185**—23, 24). **Ord.** (Trenton): Eastern Canada and U. S. A., Mississippi Valley

H. bellicincta (Hall) (**185**—28). **Ord.** (Trenton): Distribution same as preceding.

H.? major (Hall) (**185**—25–27). **M. Ord.:** Widespread throughout N. America.

H. gigantea (Billings) (**185**—22). **Ord.** (Gamachian): Eastern Canada.

H. whiteavesi Clarke and Ruedemann (**185**—29). **Sil.** (Guelph): Eastern Canada and U. S. A.

MURCHISONIA Archiac and Verneuil 1841
(= GONIOSTROPHA Oehlert 1888; HORMOTOMINA Grabau and Shimer 1909)

(**Muricites turbinatus* Schlotheim = *Turritella bilineata* Dechen). High spired, many whorled shells with rather deep sinus in outer lip culminating at about midwhorl in a short slit which generates selenizone; whorls rounded to subangular; base rounded, without umbilicus, often set off by an obscure revolving angulation; ornamentation, commonly growth lines alone but in some species elaborated by various nodes and revolving features. **Sil.–Perm., Trias.?** (widespread).

M. desiderata Hall (**186**—1, 2). **Dev.** (Onondaga): Eastern and central U. S. A.

M. maia Hall (**186**—4, 5). **Dev.** (Onondaga): Mississippi Valley.

M. vincta (Hall) (**186**—3). **Miss.** (Salem): Mississippi Valley.

M. gouldii Beede (**186**—6–8). **Perm.** (Guadalupian): Southwestern U. S. A.

GONIASMA Tomlin 1930
(= GONIOSPIRA Girty 1915)

(**Murchisonia lasallensis* Worthen). High spired, many whorled shells with moderately deep sinus in outer lip culminating in a shallow slit which generates a concave selenizone lying on under side of strongly carinate periphery; whorls strongly carinate, the carinae forming upper border of selenizone; base bordered by a double revolving ridge and rather flat within encircling ridge, without umbilicus; ornamentation, other than features mentioned, growth lines alone. **Penn., Perm.?** (N. America).

***G. lasallensis** (Worthen) (**185**—21). **Penn.:** Mississippi Valley.

STEGOCOELIA Donald 1889
(= HYPERGONIA Donald 1892)

(**Murchisonia* (*Stegocoelia*) *compacta*). High spired, many whorled shells with shallow sinus in outer lip culminating in a shallow slit that generates selenizone lying between upper pair of four or more revolving costae; base rounded, with or without minute umbilicus; ornamentation, other than the four or more revolving costae, which have relatively broad concave interspaces, growth lines alone. **Miss., Penn.** (widespread).

S. turritella (Hall) (**185**—19). **Miss.** (Salem): Mississippi Valley.

S. illinoiensis (Weller) (**185**—18). **Miss.** (Ste. Genevieve): Mississippi Valley.

S. wortheni Knight (**185**—20). **Penn.:** Mississippi Valley.

COELOCAULUS Oehlert 1888
(= VETOTUBA Etheridge, Jr., 1890; COELIDIUM Clarke and Ruedemann 1903; CATOZONE Perner 1907)

(**Murchisonia davidsoni*). Very high spired and many whorled shells with narrow umbilicus and deep, V-shaped sinus in outer lip which culminates subangularly; apex of sinus generates a broad, sometimes indistinct selenizone on whorl face. **Ord.–Dev.** (widespread).

C. macrospira (Hall) (**186**—23–25). **Sil.** (Guelph): Eastern Canada and U. S. A., Mississippi Valley.

GASCONADIA Weller and St. Clair 1928

(**Murchisonia putilla* Sardeson). Small, high spired shells with low whorls and a deep, V-shaped sinus in outer lip that culminates at obtusely subangular periphery; outer lip flares widely at mature stages; base flat, with narrow umbilicus and in fillings with a deep, transverse depression about half a whorl back from aperture. **L. Ord.** (U. S. A.).

***G. putilla** (Sardeson) (**186**—9–11). **L. Canadian:** Widespread throughout the U. S. A.

ECTOMARIA Koken 1896
(= SOLENOSPIRA Ulrich 1897)

(**Murchisonia nieszkowskii* Schmidt). Very high spired and many whorled shells with two revolving carinae on whorl face and a third carina on minutely umbilicate base; a deep, V-shaped sinus in outer lip culminates between two peripheral carinae; there is no slit or true selenizone; ornamentation, growth lines alone. **Ord.** (widespread).

E. prisca (Billings) (**186**—14). **Ord.** (Chazy): Eastern and central U. S. A.; Canada.

PLATE 187

[Figures are original by Knight unless otherwise indicated.]

1–9. Pseudozygopleura spp. 1, 2. P. semicostata. A semicostate specimen (x15); a noncostate specimen (x6). **3–5. P. wortheni** [Walker Mus (Chicago), Contr 1]. **6, 7. P. scitula.** Two specimens (x2). **8. P. kellettae.** Side view (x8). **9. P. schucherti.** Apertural view (x4). **10. Leptozyga minuta.** Side view of holotype (x30). **11. Palaeostylus cylindratus.** Side view of holotype (x6). **12, 13. Stephanozyga spp. 12. S. subnodosa.** Side view (x2). **13. S. nodosa.** Side view of a paratype showing nodes (x2). **14, 15. Helminthozyga vermicula.** An uncoiled specimen, the holotype (x30); a coiled specimen (x20). **16. Hyphantozyga gracilis.** Side view of holotype (x15). **17. Hemizyga inflata.** Side view (x6). **18. Hemizyga elegans.** Apertural view of holotype (x8). **19. Plocezyga corona.** Apertural view of holotype (x15). **20–24. Streptacis spp. 20, 21. S. scalpta.** Apertural and side views (x8). **22–24. S. whitfieldi.** Two aspects of apex, greatly enlarged [JP 5]; side view of holotype (x15). **25, 26. Donaldina stevensana.** Apertural and side views (x10). **27–29. Donaldina robusta.** Robust (x8), slender (x10), and moderately robust (x10) specimens. **30. Cyclozyga mirabilis.** Apertural view of holotype (x30). **31. Plocezyga angularis.** Apertural view (x8).

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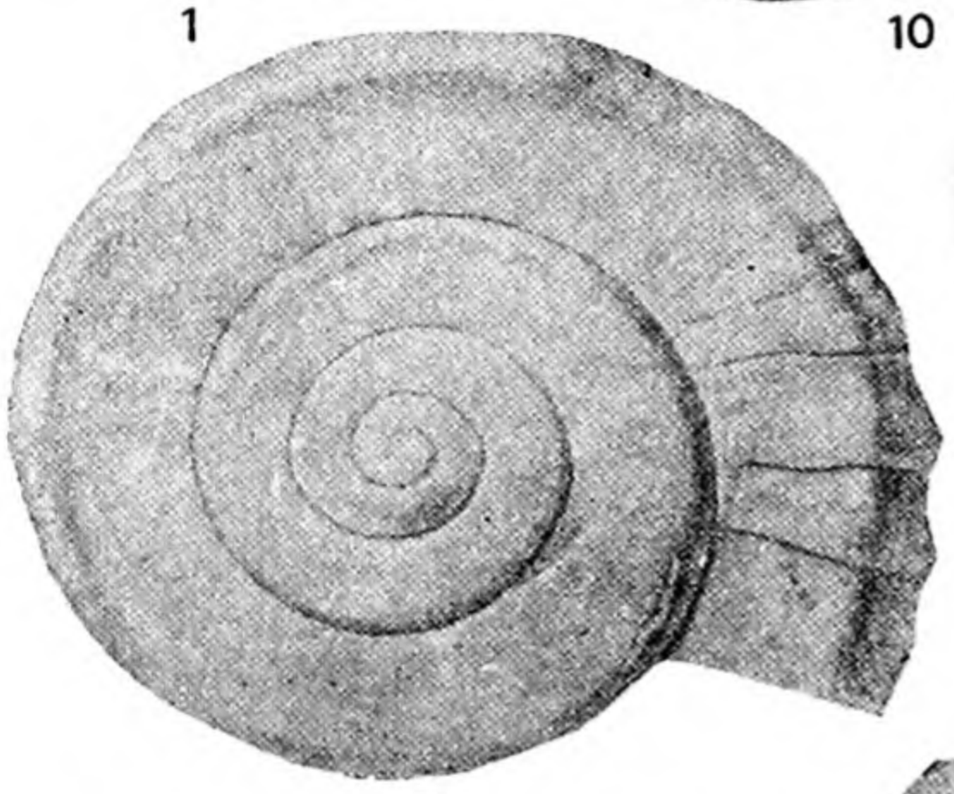
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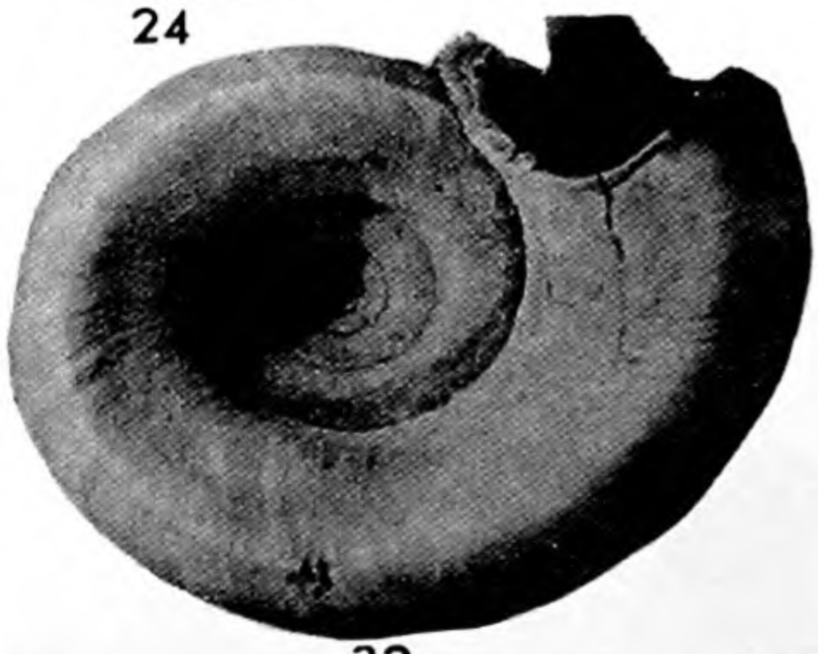
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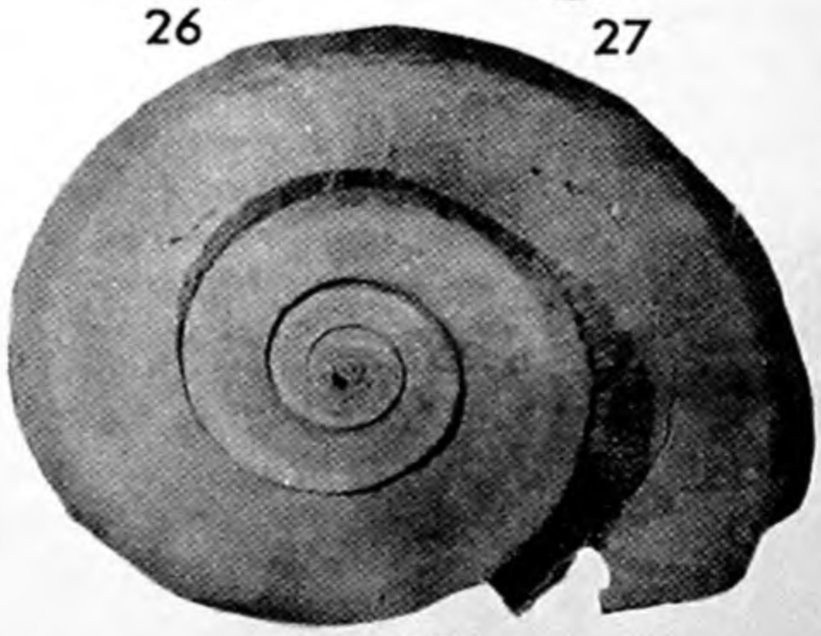
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E. pagoda (Salter) (**186**—12, 13). **Ord.** (Black River): Distribution same as preceding.

LOXONEMA Phillips 1841

(= HOLOPELLA McCoy 1851; RHABDOSTROPHA Donald 1905; PLATYCONCHA Longstaff 1933)

(**Terebra? sinuosa* Sowerby). High spired shells with U-shaped sinus in outer lip; nucleus smooth, orthostrophic; base without umbilicus; ornamentation, growth lines or transverse costae extending onto base. **Ord.–Miss.** (widespread).

L. murrayanum Salter (**186**—22). **Ord.** (Black River): Canada.

L. leda Hall (**186**—15). **Sil.** (Niagaran): Mississippi Valley.

L. hamiltoniae Hall (**186**—16). **Dev.** (Hamilton): Eastern U. S. A., Mississippi Valley.

L. delphicola Hall (**186**—17, 18). **Dev.** (Hamilton): Eastern U. S. A.

L. noe Clarke (**186**—19, 20). **Dev.** (Naples): N. Y.

L. terebra Hall (**186**—21). **Dev.** (Chemung): Eastern U. S. A.

MICROPTYCHIS Longstaff 1912

(**M. wrighti*). High spired shells with nearly straight outer lip; nucleus seemingly smooth, orthostrophic; base somewhat flattened, without umbilicus; ornamentation, on earlier whorls usually transverse, on later whorls costae confined to adpressed band just below suture where they may form a row of transversely elongated nodes; the latter condition may prevail on all postnuclear whorls. **Miss., Penn.** (widespread).

M. crenimarginatus (Knight) (**186**—28, 29). **Penn.** (Des Moines): Mississippi Valley.

EOPTYCHIA Longstaff 1933

(**Loxonema sulcatum* Koninck). High spired, conical shells with flat whorls, shallow sutures, and nearly straight outer lip; nucleus unknown; base somewhat flattened, without an umbilicus; ornamentation, rather fine transverse costae that die out on base, in some species growth lines alone. **Miss., Penn.** (widespread).

E. rothi (Knight) (**186**—27). **Penn.** (Des Moines): Mississippi Valley.

E. trochus (Knight) (**186**—26). **Penn.** (Des Moines): Mississippi Valley.

PSEUDOZYGOPLEURA Knight 1930

(**Loxonema attenuata semicostata* Meek). High spired shells with straight or gently sinuate outer lip; nucleus with deeply sinuate transverse costae; base without umbilicus; ornamentation, strong transverse costae that do not pass onto base; costae on all whorls, or on earlier whorls alone, or completely lacking; no revolving ornamentation; rare sinistral species are known. **Miss.–Perm.** (widespread).

P. wortheni (Weller) (**187**—3–5). **Miss.** (Ste. Genevieve): Mississippi Valley.

***P. semicostata** (Meek) (**187**—1, 2). **Penn.:** Mississippi Valley.

P. scitula (Meek and Worthen) (**187**—6, 7). **Penn.** (Des Moines): Mississippi Valley.

P. schucherti Knight (**187**—9). **Penn.:** Mississippi Valley.

P. kellettae Knight (**187**—8). **Penn.** (Des Moines): Mississippi Valley.

PALAEOSTYLUS Mansuy 1914

(= PYRGOZYGA Knight 1930)

(**P. pupoides*). Very high spired shells with flat, somewhat shouldered whorls and with nearly straight outer lip; nucleus with deeply sinuate costae; base rather flat, without umbilicus; ornamentation, transverse costae alone. **Penn., Perm.** (widespread).

P. cylindratus (Knight) (**187**—11). **Penn.** (Des Moines): Mississippi Valley.

LEPTOZYGA Knight 1930

(**Pseudozygopleura (Leptozyga) minuta*). Very small, high spired, somewhat pupaeform shells with straight outer lip; nucleus with deeply sinuate costae; base without umbilicus; ornamentation, fine transverse costae that do not pass onto base. **Penn.** (U. S. A.).

***L. minuta** (Knight) (**187**—10). **Penn.** (Des Moines): Mississippi Valley.

STEPHANOZYGA Knight 1930

(**Zygopleura nodosa* Girty). High spired shells with shallow sinus in outer lip; nucleus unknown; base without umbilicus; ornamentation, transverse costae that are faint or obsolete on upper part of whorl and developed to form a row of nodes at periphery. **Miss.–Perm.** (widespread).

PLATE 188

[Figures are x1 and original by Knight unless otherwise indicated.]

1–42. Straparolus spp. 1. S. (Straparolus) rudis [Pal N Y 5 (2)]. **2. S. (Serpulospira) laxus** [Pal N Y 5 (2)]. **3–5. S. (Straparolus) cyclostomus** [Ia G S 1 (2)]. **6–8. S. (Straparolus) spergenensis** [Ind G S 30]. Three views of a typical specimen. **9. S. (Serpulospira) paradoxus** [Pal N Y 5 (2)]. **10–12. S. (Euomphalus) similis** [Walker Mus (Chicago), Contr 1]. Three views of a specimen. **13, 14. S. (Euomphalus) planidorsatus** [Ill G S 2]. Apical and apertural views. **15. S. (Euomphalus) latus** [Mo G S 5]. **16, 17. S. (Straparolus) savagei.** Apertural and top views (x2). **18, 19. S. (Euomphalus) umbilicatus.** Top and basal views (x2). **20–22. S. (Euomphalus) pernodosus** [Ill G S 5]. Three views of a specimen (x0.7). **23–25. S. (Amphiscapha) catilloides.** Three views (x2). **26–28. S. (Amphiscapha) reedsi.** Three views (x2). **29–31. S. (Amphiscapha) subquadratus** [JP 8]. Oblique, top, and basal views. **32, 33. S. (Euomphalus) plummeri.** Basal and top views. **34–39. S. (Amphiscapha) subrugosus** [JP 8]. Basal, oblique apical, and apical views of a shell (x1, x2). **40–42. S. (Amphiscapha) muricatus.** Basal, oblique apical, and apical views (x2). **43. Ozarkina typica.** Views of two specimens (x2); the right is a squeeze from the holotype.

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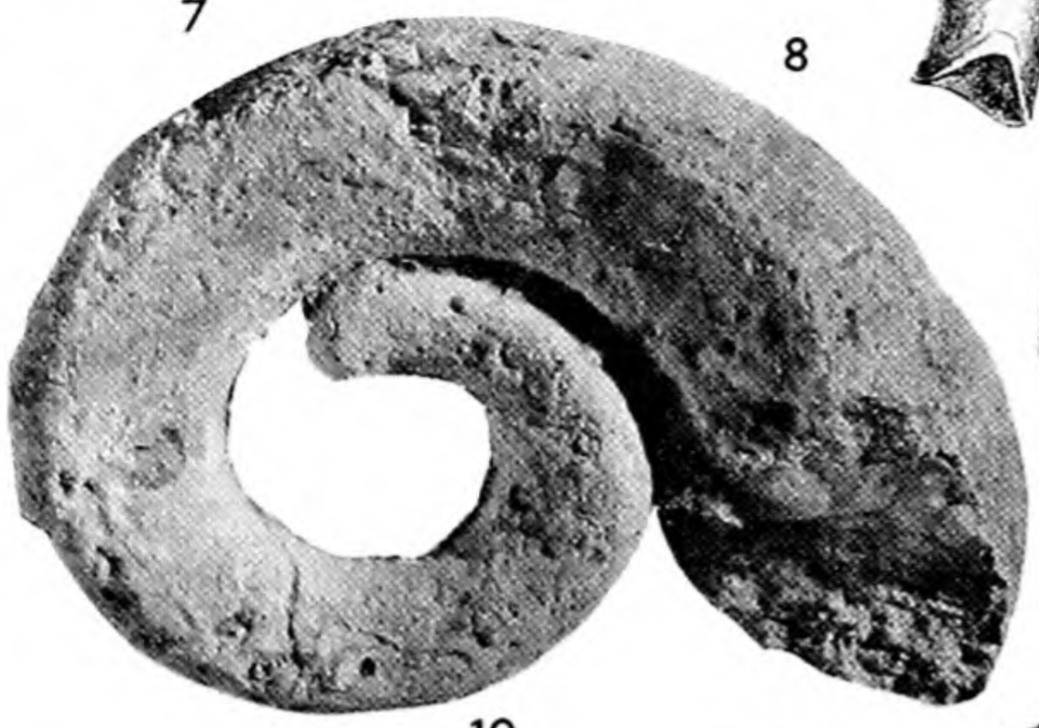

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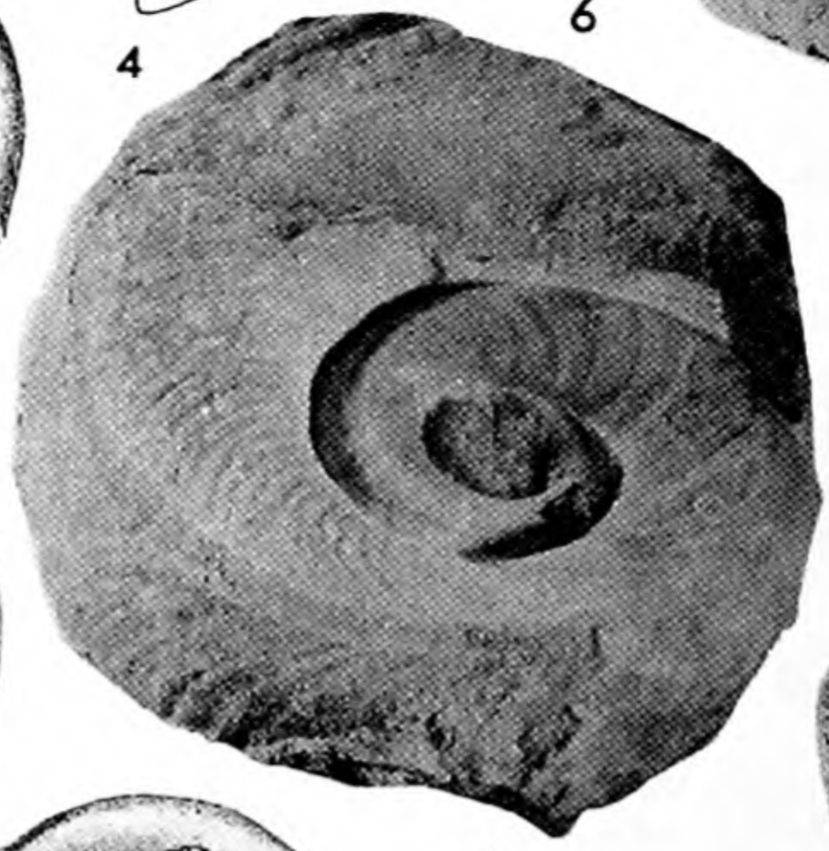

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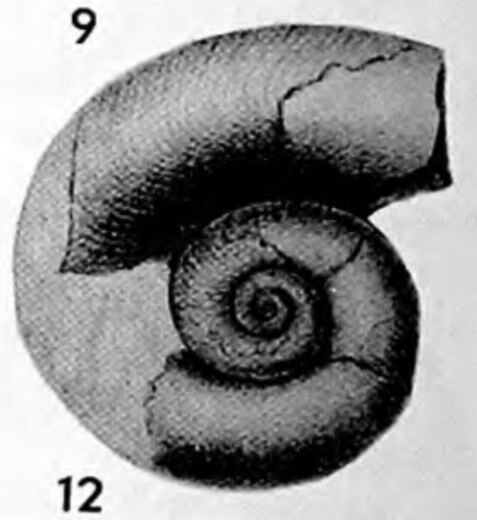

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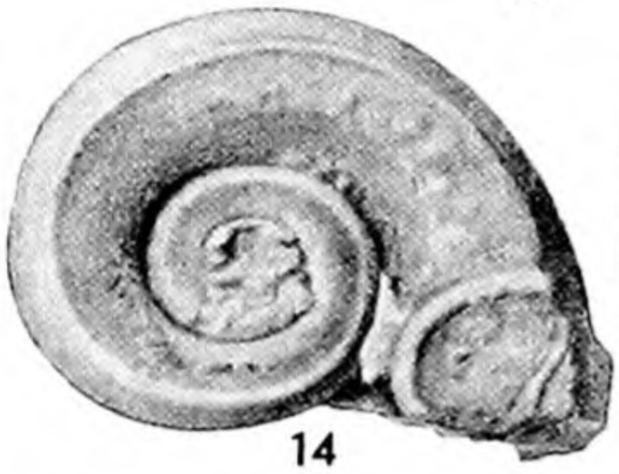

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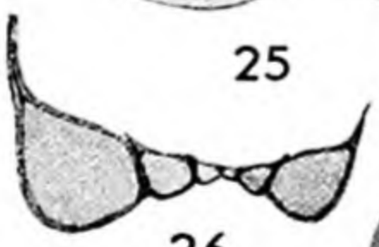

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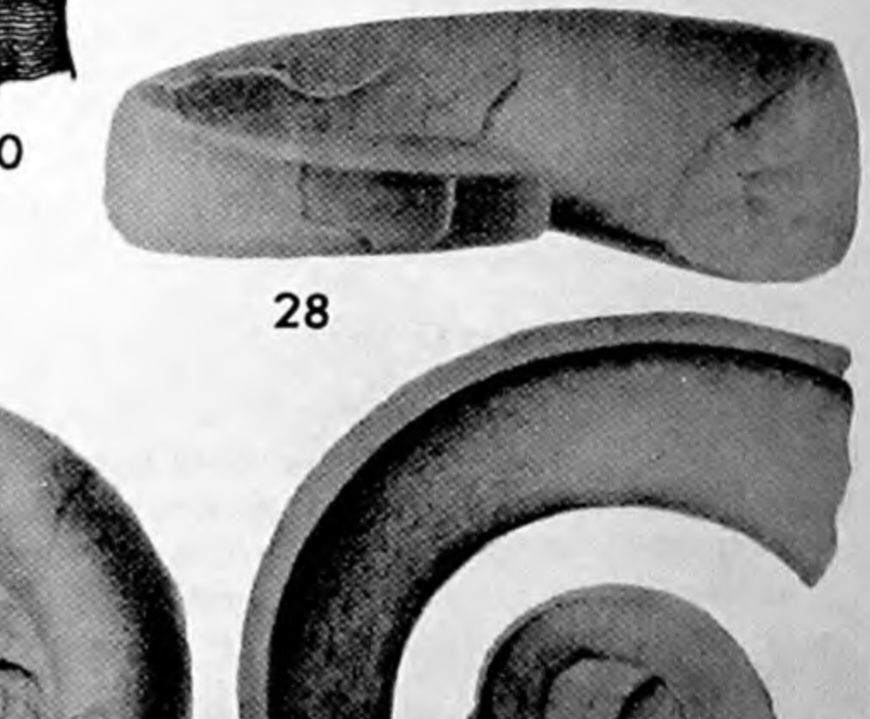

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S. subnodosa (Knight) (**187**—12). **Penn.** (Des Moines): Mississippi Valley.

***S. nodosa** (Girty) (**187**—13). **Penn.** (Virgil): Mississippi Valley.

HELMINTHOZYGA Knight 1930

(**H. vermicula*). Small shells with irregularly uncoiled whorls, fragments of which are easily mistaken for worm tubes; nucleus regularly coiled and with deeply sinuate transverse costae; ornamentation, foliaceous and varixlike transverse costae. **Miss., Penn.** (widespread).

***H. vermicula** Knight (**187**—14, 15). **Penn.** (Des Moines): Mississippi Valley.

HEMIZYGA Girty 1915

(**H. elegans*). High spired shells with nearly straight, oblique outer lip; nucleus unknown; base without umbilicus; ornamentation, transverse costae extending onto base with numerous fine revolving lirae on lower part of whorl, **Penn.** (U. S. A.).

***H. elegans** Girty (**187**—18). **Penn.** (Des Moines): Mississippi Valley.

H. inflata Knight (**187**—17). **Penn.** (Des Moines): Mississippi Valley.

PLOCEZYGA Knight 1930

(**Hemizyga* (*Plocezyga*) *corona*). High spired shells with nearly straight, oblique outer lip; nucleus with deeply sinuate transverse costae; base without umbilicus; ornamentation, strong transverse costae not extending onto base and fine revolving lirae. **Penn.** (U. S. A.).

***P. corona** (Knight) (**187**—19). **Penn.** (Des Moines): Mississippi Valley.

P. angularis (Knight) (**187**—31). **Penn.** (Des Moines): Mississippi Valley.

HYPHANTOZYGA Knight 1930

(**Hemizyga* (*Hyphantozyga*) *gracilis*). High spired shells with nearly straight outer lip; nucleus with deeply sinuate transverse costae; base without umbilicus; ornamentation, transverse and revolving costae of about equal strength extending onto base and forming network. **Dev.–Perm.** (widespread).

***H. gracilis** (Knight) (**187**—16). **Penn.** (Des Moines): Mississippi Valley.

CYCLOZYGA Knight 1930

(**C. mirabilis*). Minute high spired shells with gently sinuous, oblique outer lip; nucleus with deeply sinuate transverse costae; base without umbilicus; ornamentation, five or six strong revolving costae crossed only by fine growth lines. **Penn.** (U. S. A.).

***C. mirabilis** Knight (**187**—30). **Penn.:** Widespread throughout Mississippi Valley.

DONALDINA Knight 1933

(**Aclisina grantonensis* Donald). High spired shells with deep, rounded sinus in outer lip culminating rather high on whorl face; nucleus with first whorl in flat coil which in some species is raised free from rest of spire and tilted; base rounded, without umbilicus; ornamentation, fine revolving lirae, often doubled and typically much weaker on upper part of whorl than on lower. **Miss., Penn.** (widespread).

D. stevensana (Meek and Worthen) (**187**—25, 26). **Penn.:** Mississippi Valley.

D. robusta (Stevens) (**187**—27–29). **Penn.:** Mississippi Valley.

STREPTACIS Meek 1872

(**S. whitfieldi*). High spired shells with deep rounded sinus in outer lip culminating rather high on whorl face; nucleus with first whorl in flat coil, in some species raised free from rest of spire and tilted; base rounded, without umbilicus; ornamentation, growth lines alone, no revolving lirae. **Penn.** (N. America).

***S. whitfieldi** Meek (**187**—22–24). **Penn.:** Mississippi Valley.

S. scalpta Knight (**187**—20, 21). **Penn.:** Mississippi Valley.

STRAPAROLUS Montfort 1810

(**S. dionysii*). Conical to discoidal shells with wide umbilicus; whorls rounded or variously shouldered or angulated, in some species out of contact; without slit, selenizone, or umbilical callus, and with only a very faint sinus if any at all; earlier whorls of adults partitioned off by septa; ornamentation, usually growth lines alone but in some species faint revolving striae or in others nodes or rugosities. **Sil.–Perm.–Jura.?** (widespread).

This genus contains many species, especially in the Miss. and Penn., and it seems convenient to arrange them in the following artificial and intergrading groups, which are treated as subgenera.

STRAPAROLUS *ss* [= PHILOXENE Kayser 1889]. Whorls in contact, rounded or only obscurely

PLATE 189

[Figures are x1 unless otherwise indicated; drawings from Minn G S 3 (2) and photographs original by Knight unless otherwise indicated.]

1–8. Lytospira spp. 1, 2. L. priscus [AMNH, B 2 (2)]. **3, 4. L. proclivis** [Carnegie Mus, An 4]. Top view and section. **5, 6. L. undulatus.** Side and top views. **7, 8. L. subrotundus.** Side and top views of an internal filling showing rounded section, elevated line near base, and deep sinus in upper lip. **9. Helicotoma planulata.** Oblique view of holotype (x2). **10, 11. Pleuronotus decewi.** An internal filling and oblique view of another specimen. **12, 13. Sinutropis fairchildi** [N Y St Mus, M 5]. Two views of a broken specimen. **14–17. Helicotoma spp. 14, 15. H. unilangulata** [14 is from an unpublished photograph furnished by J. Bridge; 15: Ala G S, SPR 14]. **16, 17. H. umbilicata.** Two views of a large specimen. **18–20. Ophiletina subiaxa.** Top view; cross section of whorl; portion of surface enlarged (x3). **21–30. Eculiomphalus spp. 21, 22. E. triangulus.** Two views of an internal filling. **23–25. E. beloitensis.** Apertural, top, and side views. **26, 27. E. owenanus.** Vertical section of a shell; a broken internal filling. **28–30. E. volutatus** [AMNH, B 1 (8)]. **31. Orospira bigranosa.** Slab showing three specimens (x2). **32–34. Lecanospira compacta.** Basal view [CGS, COR d 1]; external impression of upper surface (x2); oblique view of the holotype (x2), an internal filling.

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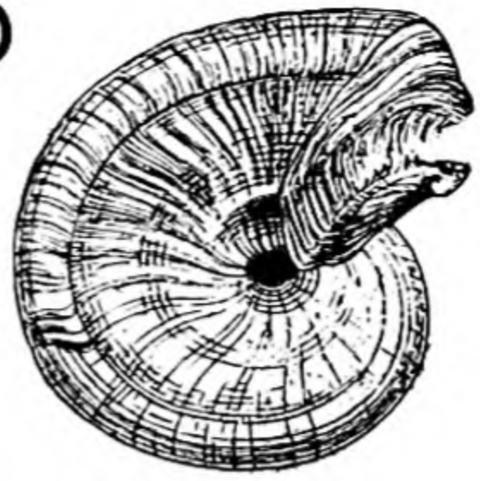

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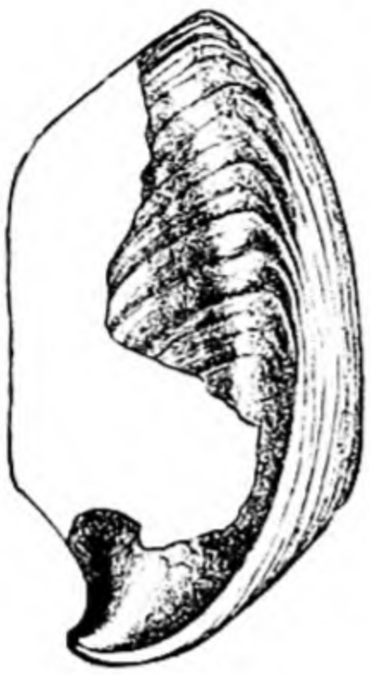

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shouldered or angulated; in some species shell fragments are cemented to periphery. **Dev.–L. Penn.** (widespread).

SERPULOSPIRA Cossman 1915 [= SERPULARIA Roemer 1843; PAROMPHALUS Grabau 1936] (**Serpularia centrifuga* Roemer). Similar to preceding but with all but earlier whorls out of contact. **Dev.–Perm.** (widespread).

EUOMPHALUS Sowerby 1814 [= SCHIZOSTOMA Bronn 1834; PHYMATIFER Koninck 1881] (**E. pentangularis*). Similar to *Straparolus ss* but always with a well marked shoulder within a well developed angulation, and frequently other less strongly developed angulations as well; some species with nodes on upper angulation, on base, or on both; umbilicus rather deep. **Sil.–Perm.** (widespread).

AMPHISCAPHA Knight 1942 (**Straparolus* (*Euomphalus*) *reedsi*). Discoidal shells with spire depressed and umbilicus very wide and shallow; carinae usually rugose, at outer margins of both upper and under surfaces. **Penn., Perm.** (N. America).

S. (Serpulospira) laxus (Hall) (188—2). **Dev.** (Onondaga, Hamilton): N. Y.

S. (Straparolus) rudis (Hall) (188—1). **Dev.** (Hamilton): N. Y.

S. (Straparolus) cyclostomus (Hall) (188—3–5). **M. Dev.:** Ia.

S. (Serpulospira) paradoxus (Winchell) (188—9). **Miss.** (Burlington): Mississippi Valley.

S. (Straparolus) spergenensis Hall (188—6–8). **Miss.** (Salem): Mississippi Valley.

S. (Euomphalus) latus (Hall) (188—15). **Miss.** (Meramec): Mississippi Valley.

S. (Euomphalus) similis Meek and Worthen (188—10–12). **Miss.** (Meramec): Mississippi Valley.

S. (Euomphalus) planidorsatus (Meek and Worthen) (188—13, 14). **Miss.** (Chester): Mississippi Valley.

S. (Straparolus) savagei Knight (188—16, 17). **Penn.** (Smithwick): Southwestern U. S. A.

S. (Euomphalus) pernodosus Meek and Worthen (188—20–22). **Penn.** (Des Moines): Mississippi Valley.

S. (Euomphalus) umbilicatus (Meek and Worthen) (188—18, 19). **Penn.** (Des Moines): Mississippi Valley.

S. (Amphiscapha) catilloides (Conrad) (188—23–25). **Penn.:** Mississippi Valley.

S. (*Amphiscapha) reedsi Knight (188—26–28). **Penn.** (Des Moines): Mississippi Valley.

S. (Euomphalus) plummeri Knight (188—32, 33). **Penn.** (Missouri): Mississippi Valley.

S. (Amphiscapha) subquadratus Meek and Worthen (188—29–31). **Penn.:** Mississippi Valley.

S. (Amphiscapha) subrugosus (Meek and Worthen) (188—34–39). **Penn.:** Mississippi Valley.

S. (Amphiscapha) muricatus Knight (188—40–42). **Perm.** Midcontinent region.

OZARKINA Ulrich and Bridge 1931

(**O. typica*). Discoidal shells with many narrow, rounded whorls; flat on top and with wide, shallow umbilicus; ornamentation, growth lines alone. **L. Ord.** (U. S. A.).

***O. typica** U and B (188—43). **Gasconade:** Mississippi Valley.

LYTOSPIRA Koken 1896

(= LIOMPHALUS Chapman 1916)

(**Euomphalus angelini* Lindstroem). Discoidal shells, usually loosely coiled and with at least the later whorls out of contact; sinus in upper edge of lip culminates without slit on upper whorl surface usually at crest of a low angulation; earlier whorls partitioned; ornamentation, growth lines that are usually rather coarse; some species cement shell fragments to outer surface. **Ord., Sil.** (widespread).

L. priscus (Whitfield) (189—1, 2). **Canadian:** Northeastern U. S. A.

L. proclivis (Raymond) (189—3, 4). **Chazy:** Northeastern U. S. A.

L. undulatus (Hall) (189—5, 6). **Black River:** Mississippi Valley.

L. subrotundus (Ulrich and Scofield) (189—7, 8). **Trenton:** Mississippi Valley.

PLEURONOTUS Hall 1879

(**Euomphalus decewi* Billings). Discoidal shells with depressed spire and wide umbilicus; whorls subangularly shouldered; a deep V-shaped sinus in outer lip culminating at crest of angulation in a short notchlike slit which generates selenizone; earlier whorls partitioned; ornamentation, growth lines. **M. Dev.** (widespread).

***P. decewi** (Billings) (189—10, 11). **Onondaga:** Canada; Mississippi Valley.

SINUTROPIS Perner 1903

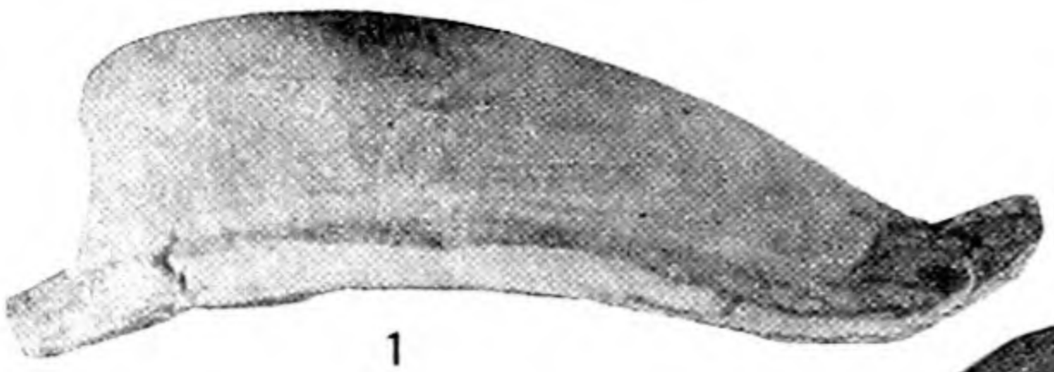
(**S. esthetica*). Discoidal shells with rounded whorls and a U-shaped sinus in upper part of outer lip; spire only slightly protruding; umbilicus wide; ornamentation, growth lines and in some species fine revolving lirae. **Sil.** (widespread).

S. fairchildi (Clarke and Ruedemann) (189—12, 13). **Guelph:** Northeastern N. America.

PLATE 190

[Figures are x1 unless otherwise indicated.]

1–14. Maclurites spp. 1–6. M. magnus (x0.5) [Carnegie Mus, An 4]. Lower and upper views of a characteristic shell; two views of large operculum; side view of same shell as preceding; side view of same operculum as preceding. **7–9. M. logani** (x0.7) [CGS, COR d 1]. Upper and apertural views of a young specimen with operculum in place; operculum of an adult shell. **10. M. manitobensis** [J. B. Knight original]. Oblique apertural view. **11–14. M. logani** [prints furnished by J. Bridge]. Apertural, side, lower, and upper views of a nearly complete shell with operculum in place. **15 ,16. Maclurites stantoni** [J. B. Knight original]. Apertural and top views of holotype (x4).



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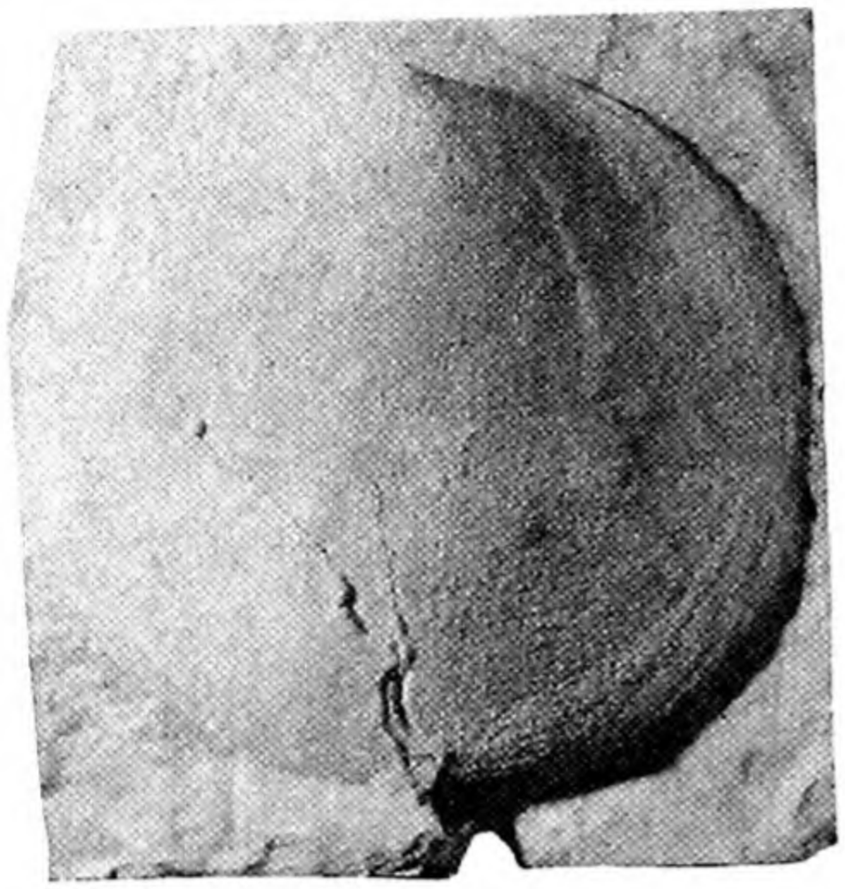

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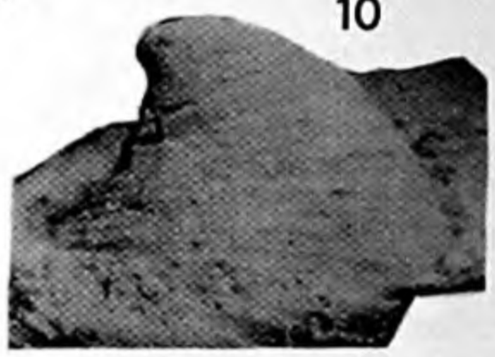

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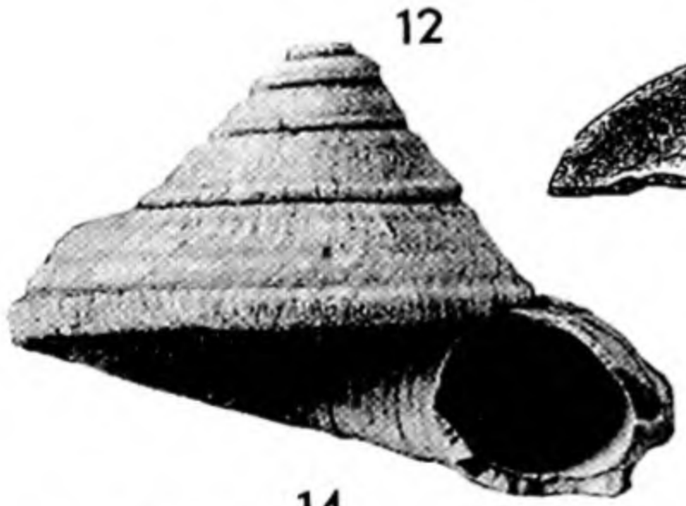

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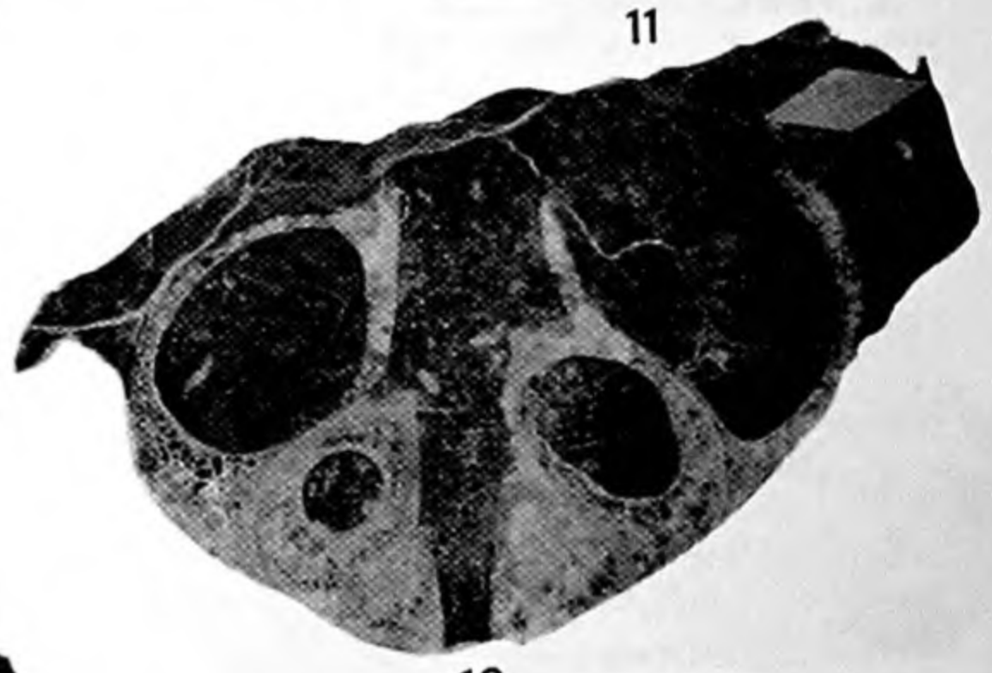

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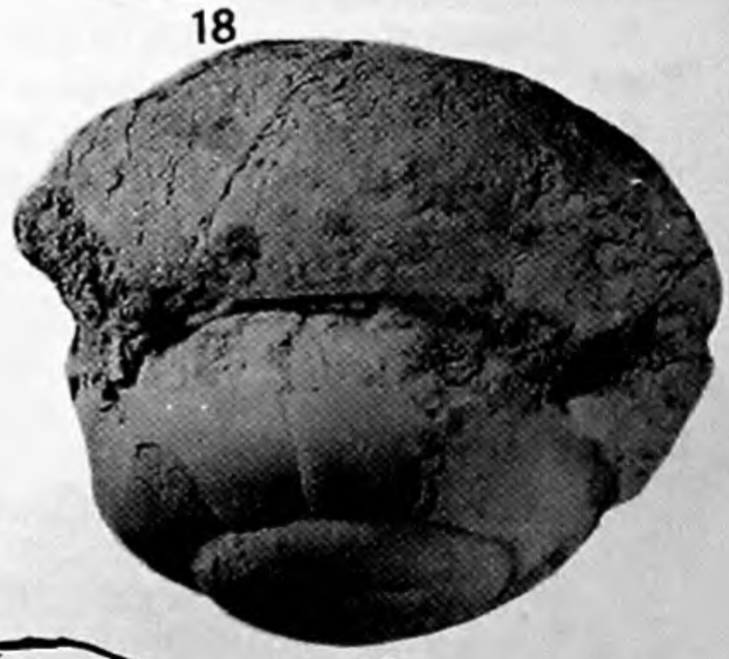

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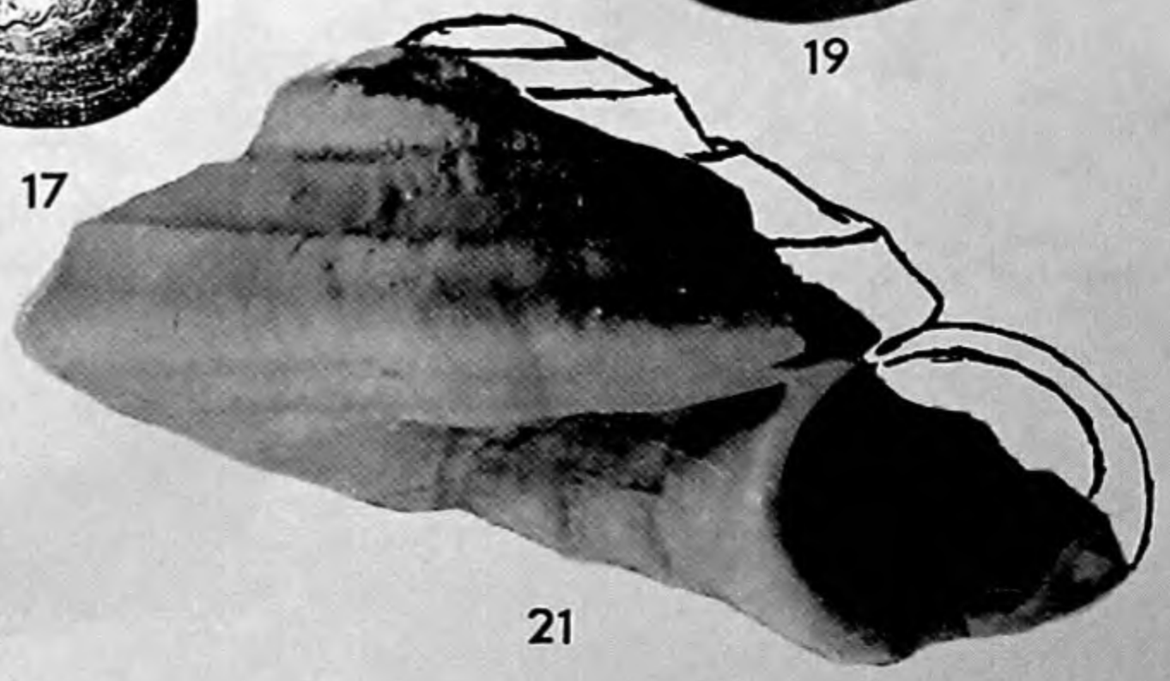

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HELICOTOMA Salter 1859

(= PALAEOMPHALUS Koken 1925)

(**H. planulata*). Discoidal shells with wide umbilicus and slightly protruding spire; whorls strongly shouldered with a well marked carina at shoulder angle; a deep V-shaped sinus culminates at crest of shoulder angle in a short notchlike slit which often generates a selenizone; ornamentation, growth lines and often faint revolving striae. **Ord.** (widespread).

H. uniangulata (Hall) (**189**—14, 15). **Canadian:** Eastern U. S. A., Mississippi Valley, Tex.

***H. planulata** (Salter) (**189**—9). **Black River:** Canada; eastern U. S. A., Mississippi Valley.

H. umbilicata Ulrich and Scofield (**189**—16, 17). **Black River:** Mississippi Valley.

OROSPIRA Butts 1926

(**O. bigranosa*). Discoidal shells with wide umbilicus and slightly protruding spire; whorls strongly shouldered with well marked carina at shoulder angle; a V-shaped sinus culminates at crest of shoulder angle in a short notchlike slit which often generates a selenizone; ornamentation rather elaborate, consisting of revolving costae near upper suture and on base and of growth lines which often are fasciculated to form nodes on revolving costae. **L. Ord.** (N. America).

***O. bigranosa** Butts (**189**—31). **U. Canadian:** Appalachians (Knox), Wis. and Minn. (Shakopee), Mo. (Cotter), Okla. (Arbuckle), Tex. (Ellenburger).

OPHILETINA Ulrich and Scofield 1897

(**O. sublaxa*). Discoidal shells with several revolving angulations or carinae; a shallow sinus in outer lip culminates just above shoulder angulation in a notchlike slit which generates a selenizone lying between two lirae; last whorl often out of contact; ornamentation, foliaceous growth lamellae. **Ord.** (N. America).

***O. sublaxa** U and S (**189**—18–20). **Mohawkian:** Mississippi Valley.

LECANOSPIRA Butts 1926

(**Ophileta compacta* Salter). Discoidal shells with depressed spire and flat base showing all the whorls; whorls narrow and numerous, flat or rounded below, sharply angular above; outer lip with deep V-shaped sinus culminating at sharp upper angle of whorls; ornamentation, growth lines alone. **L. Ord.** (widespread).

***L. compacta** (Salter) (**189** 32 34). **Canadian:** Widespread throughout eastern and central N. America.

ECCULIOMPHALUS Portlock 1843

(= ECCYLOPTERUS Remelé 1888)

(**E. bucklandi*). Discoidal shells, usually loosely coiled and usually with at least the later whorls out of contact; a V-shaped sinus in outer lip culminates at outer margin of upper surface in a high, thin carina; there is no slit or selenizone; earlier whorls partitioned; ornamentation, growth lines or transverse lirae. **Ord., Sil.** (widespread).

E. volutatus Whitfield (**189**—28–30). **Canadian:** Canada; northeastern U. S. A.

E. triangulus Whitfield (**189**—21, 22). Same as preceding.

E. beloitensis (Ulrich and Scofield) (**189**—23–25). **Black River:** Mississippi Valley.

E. owenanus (Meek and Worthen) (**189**—26, 27). **Trenton:** Mississippi Valley.

EUOMPHALOPTERUS Roemer 1876

(= BATHMOPTERUS Kirk 1928)

(**Turbinites alatus* Wahlenberg). Conical, somewhat turreted shells with wide umbilicus and wide frill-like peripheral carina; ornamentation, growth lines, in some species fasciculate or foliaceous. **Sil.** (widespread).

E. obsoletus Ulrich and Scofield (**191**—8–10). **Niagaran:** Mississippi Valley.

OMPHALOTROCHUS Meek 1864

(**O. whitneyi*). Conical or conical-turreted shells with wide umbilicus and rounded sinus in upper part of outer lip, the lower part of lip protruding markedly forward below sinus; ornamentation, various revolving ridges or angulations and transverse growth lines. **Perm.** (widespread).

***O. whitneyi** Meek (**191**—21). **Wolfcamp:** Southwestern U. S. A.

O. obtusispira (Shumard) (**191**—12–15). **Wolfcamp:** Southwestern U. S. A.

O. ferrieri Girty (= **O. conoideus** Girty) (**191**—5–7). **Phosphoria:** Northwestern U. S. A.

MACLURITES Lesueur 1818

(= MACLUREA Emmons 1842)

MACLURINA Ulrich and Scofield 1897)

(**M. magnus*). Large, hyperstrophic (pseudosinistral) shells with all whorls visible on flat lower side

PLATE 191

[Figures are x1 and original by Knight unless otherwise indicated.]

1, 2. Archinacella powersi. Side and top views of a squeeze from an external impression (x2). **3, 4. Lepetopsis levetti.** Top and left side views of holotype (x2). **5–7. Omphalotrochus ferrieri** [USGS, B 436]. Apertural, side, and top views. **8–10. Euomphalopterus obsoletus** [Minn G S 3 (2)]. Apertural, basal, and top views. **11. Lepetopsis haworthi.** Side view (x6). **12–15. Omphalotrochus obtusispira** [JP 11]. Basal, top, apertural, and side views. **16, 17. Archinacella deformata** [Carnegie Mus, An 4]. Side and top views. **18–20. Palliseria** spp. **18, 19. P. longwelli.** Vertical section; oblique view showing protruding base. **20. P. robusta.** Holotype viewed from below showing rounded, produced, spirelike base and growth lines near aperture. **21. Omphalotrochus whitneyi.** Apertural view of a broken specimen, partly restored.

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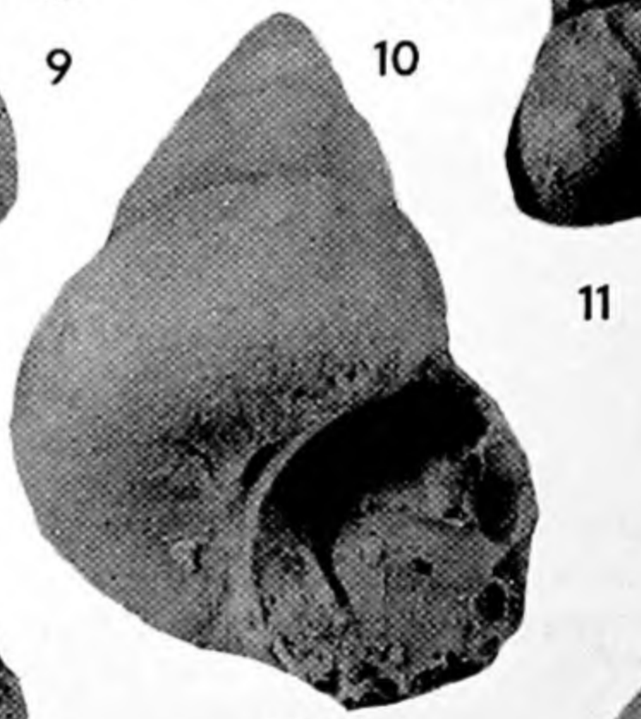
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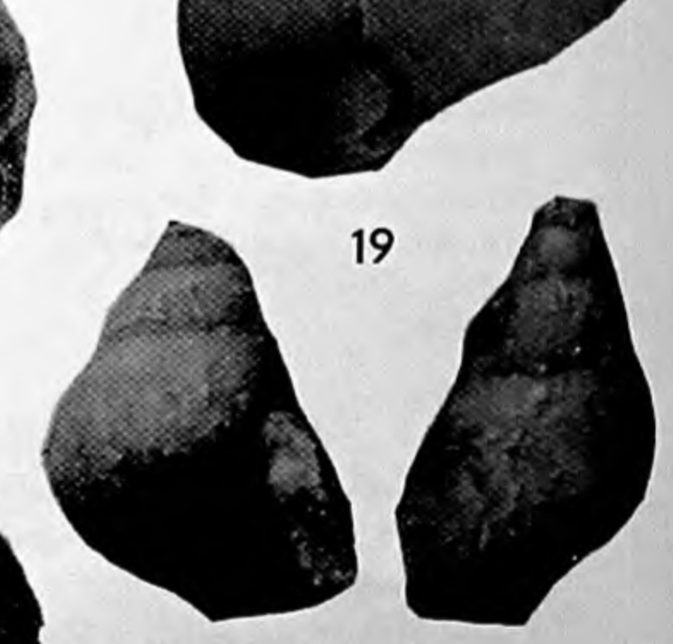
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and a deep, often wide umbilicus on convex upper side; opercular plate which if horn-shaped has rugose projections on inner side for muscle attachment; ornamentation, growth lines and in some species revolving striae or grooves. **Ord.** (widespread). (This genus is very abundant in the Ord. rocks of N. Amereia but the specimens commonly are poorly preserved, hence it is often difficult to distinguish species.)

***M. magnus** Lesueur (**190**—1–6). **Chazy:** Eastern N. America.

M. logani (Salter) (**190**—7–9, 11–14). **Black River:** Canada.

M. manitobensis (Whiteaves) (**190**—10). **Bighorn** and equivalents: Great Plains and Rocky Mts. of Canada and U. S. A.

MACLURITELLA Kirk 1927

(**M. stantoni*). Small, pseudosinistral shells with an arched, umbilicate, upper and flat lower surface; whorls not in contact; operculum unknown; ornamentation, growth lines alone. **L. Ord.** (western N. America).

***M. stantoni** Kirk (**190**—15, 16). **Manitou:** Colo.

PALLISERIA Wilson 1924

(= MITROSPIRA Kirk 1930)

(**P. robusta*). Large, pseudosinistral shells with all the whorls visible on strongly convex, spirelike, lower side and a deep umbilicus on convex upper side; umbilicus surrounded with sharply angular carina; operculum unknown; ornamentation, growth lines alone. **Ord.** (N. America).

P. longwelli (Kirk) (**191**—18, 19). **Chazy:** Great Basin region.

***P. robusta** Wilson (**191**—20). **Richmond:** Canada; Rocky Mts.

ARCHINACELLA Ulrich and Scofield 1897

(**A. powersi*). Patelliform shells with apex overhanging anterior end; aperture subelliptical; muscle scar a continuous band, wide over most of shell and very narrow under apex; ornamentation, growth lines. **Ord., Sil.** (widespread).

A. deformata (Hall) (**191**—16, 17). **Chazyan:** Eastern N. America.

***A. powersi** U and S (**191**—1, 2). **Mohawkian:** Northern Mississippi Valley.

LEPETOPSIS Whitfield 1882

(**Patella levetti* White). Patelliform shells with subcentral apex tilted slightly toward anterior end; aperture subelliptical; muscle scar a continuous horseshoe-shaped band open at anterior end; ornamentation, growth lines. **Sil.?, Miss.–Perm.** (widespread).

***L. levetti** (White) (**191**—3, 4). **Miss.** (Salem): Mississippi Valley.

L. parrishi Gurley (**192**—1, 2). **Penn.** (Missouri): Mississippi Valley.

L. haworthi (Beede) (**191**—11). **Perm.** (Guadalupian): Mississippi Valley, southwestern U. S. A.

HOLOPEA Hall 1847

(= LITIOPSIS Salter 1866; HAPLOSPIRA Koken 1897; CIRROPSIS Perner 1903; RAPHISPIRA Perner 1903; TORTILLA Perner 1903; STAUROSPIRA Perner 1907; ANASTROPHINA Knight 1937)

(**H. symmetrica*). Turbinate shells with rounded whorls, deep sutures, a rounded narrowly umbilicate base and a nearly straight outer lip; apertural margins thin throughout; a few species show flattened shoulder, some a circumumbilical costa and some are coiled with whorls out of contact; ornamentation, growth lines and in some species wide transverse undulations. **Ord., Sil.**

H. ampla Ulrich and Scofield (**192**—3, 4). **Black River:** U. Mississippi Valley.

H. pyrene Billings (**192**—5, 6). **Black River, Trenton:** Canada; U. Mississippi Valley.

H. rotunda Ulrich and Scofield (**192**—7). **Black River, Trenton:** Mississippi Valley.

***H. symmetrica** Hall (**192**—8). **Trenton:** Eastern N. America.

STRAPAROLLINA Billings 1865

(**S. pelagica*). Trochiform shells with only moderately deep sutures, nearly straight outer lip and a sharp ridge, generated by thickening of lower angle of columellar lip, surrounding a narrow umbilicus; ornamentation, growth lines alone. **Ord.** (N. America).

***S. pelagica** Billings (**192**—12, 13). **Canadian:** Northeastern N. America.

S. eurydice Billings (**192**—14, 15). **Black River:** Northeastern N. America.

ELASMONEMA Fisher 1885

(= CALLONEMA Hall 1879)

(**Loxonema bellatulum* Hall). Turbinate shells with

PLATE 192

[Figures are x1 and original by Knight unless otherwise indicated.]

1, 2. Lepetopsis parrishi [JP 9]. Top view (x2); side view. **3–8. Holopea** spp. [3–7: Minn G S 3 (2)]. **3, 4. H. ampla.** Apertural and basal views of a large specimen. **5, 6. H. pyrene.** Apertural and top views. **7. H. rotunda.** Apertural view. **8. H. symmetrica.** Apertural view (x4). **9–11. Microdoma conicum.** Views of three specimens (x5). **12–15. Straparollina** spp. **12, 13. S. pelagica.** Apertural and side views (x2). **14, 15. S. eurydice** [Can Nat G (1) 5]. **16–21. Anematina** spp. **16, 17. A. marshalli** [AJS (4) 38]. Apertural and side views (x4). **18, 19. A. proutana** (x6). Oblique apertural view; side view. **20, 21. A. minutissima.** Apertural and side views (x20). **22–24. Elasmonema** spp. (x2). **22, 23. E. elegans.** Side views. **24. E. bellatulum. 25–31. Cyclonema** spp. [25–28: Minn G S 3 (2); 29: CGS, M 154]. **25, 26. C. varicosum.** Side view; apertural view of another specimen. **27, 28. C. mediale.** Basal and side views. **29. C. percingulatum.** Apertural view (x2). **30, 31. C. bilix.** Apertural and side views (x2). **32, 33. Araeonema virgatum** (x20). Oblique apertural view; side view of large specimen.

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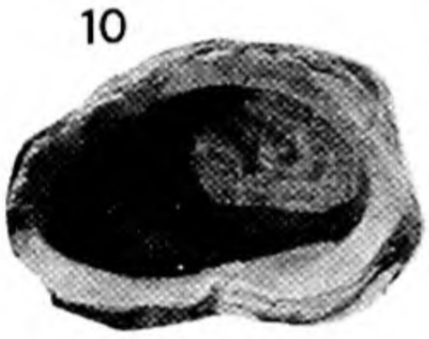

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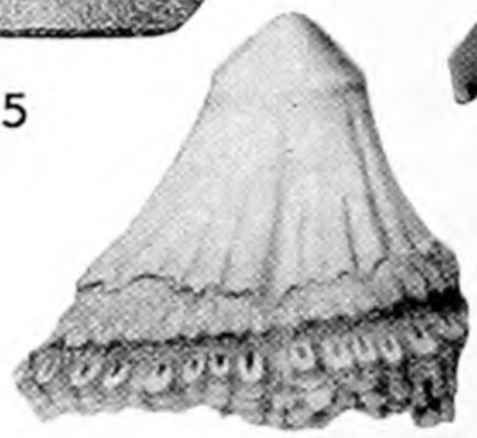

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shallow sutures; outer lip oblique and sometimes slightly sinuous; whorls usually flatly arched but sometimes shouldered; base rounded or flatly rounded with narrow umbilicus; ornamentation, transverse lirae. **Dev.** (N. America).

E. elegans (Hall) (**192**—22, 23). **Helderberg:** Eastern U. S. A.

***E. bellatulum** (Hall) (**192**—24). **Onondaga:** Mississippi Valley.

ANEMATINA Knight 1933

(**Holopea proutana* Hall). Turbinate shells with gently arched whorls and shallow sutures; base minutely umbilicated; outer lip oblique; ornamentation, growth lines and in some species fine revolving lirae on base. **Miss., Penn.** (N. America).

***A. proutana** (Hall) (**192**—18, 19). **Miss.** (Salem): Mississippi Valley.

A. marshalli (Roundy) (**192**—16, 17). Same as preceding.

A. minutissima (Knight) (**192**—20, 21). **Penn.** (Des Moines): Mississippi Valley.

CYCLONEMA Hall 1852

(**Pleurotomaria bilix* Conrad). Turbinate shells with oblique outer lip and thickened and excavated columellar lip; base rounded or slightly flattened, without umbilicus or callus; ornamentation, numerous revolving lirae or costae and fine transverse lirae or growth lines. **Ord., Sil.**

C. varicosum Hall (**192**—25, 26). **Trenton:** Mississippi Valley.

***C. bilix** (Conrad) (**192**—30, 31). **Richmond:** Mississippi Valley.

C. mediale Ulrich and Scofield (**192**—27, 28). **Cincinnatian:** Mississippi Valley.

C. percingulatum Billings (**192**—29). **Niagaran:** Eastern Canada.

MICRODOMA Meek and Worthen 1867

(= TUBERCULOPLEURA Jakowlew 1899;

PLEUROTROCHUS Sherzer and Grabau 1908)

(**M. conicum*). Rather high spired trochiform shells with an oblique, nonsinuate outer lip; base flatly arched, with minute umbilicus; ornamentation at early ephebic stage, strong rounded transverse costae which are soon broken up into nodes arranged in three revolving rows. **Dev.–Perm.** (widespread).

***M. conicum** M and W (**192**—9–11). **Penn.** (Des Moines): Mississippi Valley.

ARAEONEMA Knight 1933

(= TURBINA Koninck 1881;

PALAEOTURBINA Wenz 1938)

(**A. virgatum*). Small, trochiform shells with straight outer lip; lip margins thin; base rounded, with minute umbilicus; ornamentation, growth lines alone or with fine revolving lirae. **Miss., Penn.** (widespread).

***A. virgatum** Knight (**192**—32, 33). **Penn.** (Des Moines): Mississippi Valley.

EUCOCHLIS Knight 1933

(**E. perminuta*). Minute turbinate shells with nearly straight, oblique outer lip; base rounded, without umbilicus; ornamentation, transverse costae. **Penn.** (N. America).

***E. perminuta** Knight (**193**—20). **Penn.:** Mississippi Valley. (Often abundant in collections of microscopic fossils.)

PYCNOMPHALUS Lindstroem 1884

(**P. obesus*). Shell rotelliform with many rounded, moderately embracing whorls; outer lip nearly straight; base rounded, with umbilicus surrounded by a flange of callus projecting into it; ornamentation, growth lines alone. **Sil.** (widespread).

P. solarioides (Hall) (**193**—21–23). **Guelph:** Northeastern N. America.

ISONEMA Meek and Worthen 1866

(**I. depressum* = *I. humile* Meek). Somewhat lenticular, turbinate shells with deeply embracing whorls and a sharply rounded periphery; outer lip straight and oblique; base flatly arched, with thickened parietal inductura covering umbilical region; ornamentation, fine often fasciculated transverse lirae. **Dev.** (N. America).

***I. humile** Meek (**193**—24). **Onondaga:** Mississippi Valley.

ANOMPHALUS Meek and Worthen 1867

(= ANTIROTELLA Cossmann 1918)

(**A. rotulus*). Shell rotelliform, with rounded deeply embracing whorls; outer lip nearly straight; base rounded, with umbilicus surrounded by, or completely closed by, callus; ornamentation, very faint growth lines alone. **Dev.–Penn.** (widespread).

PLATE 193

[Figures are x1 and original by Knight unless otherwise indicated.]

1–19. Platyceras spp. **1, 2. P. (Platyostoma) cornutum** [Pal N Y 2]. Top and apertural views of partly exfoliated specimen. **3, 4. P. (Platyostoma) ventricosum.** Apertural and oblique side views. **5–7. P. (Platyceras) unguiforme** [Pal N Y 3]. Three specimens illustrating variation in form and sculpture. **8. P. (Orthonychia) tribulosum** [Pal Mo 2]. Dorsal view. **9. P. (Platyceras) haliotoides** [Pal Mo 2]. Apertural view. **10. P. (Platyceras) niagarense** [Pal N Y 2]. **11, 12. P. (Orthonychia) parvum.** Apertural and side views (x2). **13, 14. P. (Platyostoma) turbinatum** [Pal N Y 5 (2)]. Top and side views of different specimens. **15, 16. P. (Platyceras) dumosum** [Pal N Y 5 (2)]. Top and side views of type (x0.7). **17. P. (Orthonychia) conicum** [Pal N Y 5 (2)]. **18. P. (Orthonychia) quincyense** [Pal Mo 2]. **19. P. (Orthonychia) subrectum.** Side view (x4). **20. Eucochlis perminuta.** Apertural view of holotype (x30). **21–23. Pycnomphalus solarioides** [CGS, Pal Fos 3]. Vertical section; top and side views. **24. Isonema humile.** Apertural view (x2). **25–29. Anomphalus** spp. **25, 26. A. rotulus** (x10). Oblique apertural view; basal view. **27–29. A. umbilicatus.** Apertural, basal, and top views (x5).

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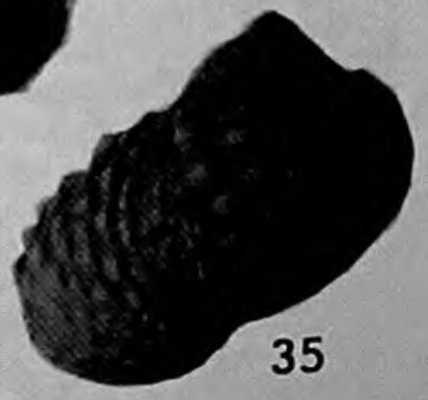
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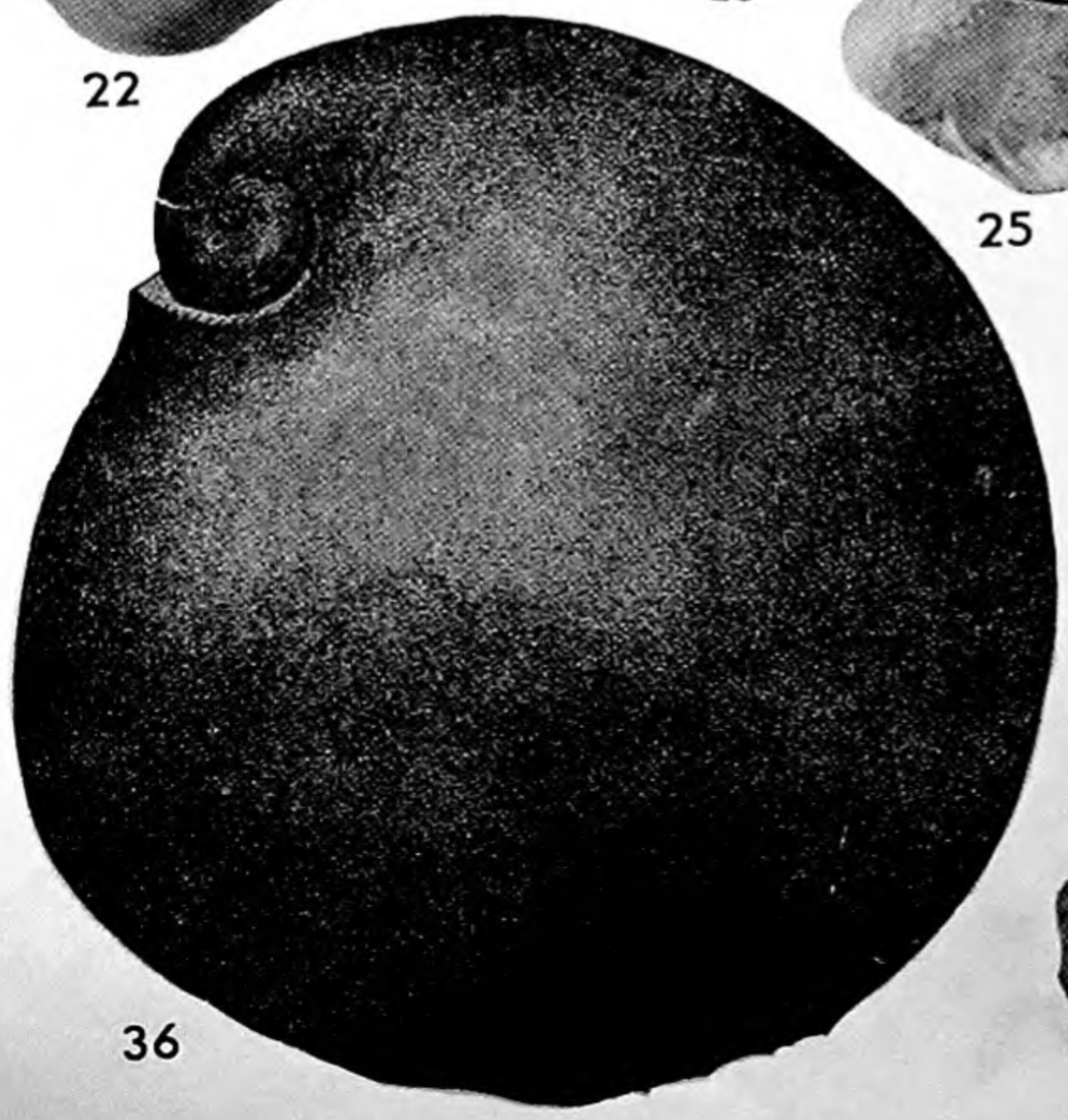
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***A. rotulus** M and W (**193**—25, 26). **Penn.:** Mississippi Valley.

A. umbilicatus Knight (**193**—27–29). Same as preceding.

TURBONOPSIS Grabau and Shimer 1909

(**Turbo shumardi* Hall). Large turbinate shells with oblique, convex outer lip and conspicuous rounded carina around periphery; base rounded, without an umbilicus; inner lip thickened and channeled; ornamentation, growth lines and prominent oblique, knoblike ridges crossing shoulder angle. **Dev.** (N. America).

***T. shumardi** (Hall) (**194**—1, 2). **Onondaga:** Mississippi Valley.

PLATYCERAS Conrad 1840

(**Pileopsis vetusta* Sowerby). Naticiform to horn-shaped shells characterized by irregularities of growth reflecting irregularities of substratum to which shell was fixed during much of its life; shell is thin and apertural margin is thin without fixed physiological modifications; shell resists solution fairly well and hence is often well preserved; ornamentation includes fine revolving and transverse elements and in some species coarse, hollow spines. **Sil.–Perm.** (widespread).

Individual variation in this genus makes specific discrimination exceedingly difficult and it is impractical to include many species in a work of this scope; individuals are often numerous and a large number of species have been described. It seems convenient to arrange the species in the following artificial and intergrading groups that are here treated as subgenera.

PLATYOSTOMA Conrad 1842 [= DIAPHOROSTOMA Fischer 1885; PLATYCERINA Miller 1889; VISITATOR Perner 1911; AULOPEA Dunbar 1920; DISTEMNOSTOMA Dunbar 1920; SAFFORDELLA Dunbar 1920] (**P. ventricosum*). Naticiform shells with whorls coiled in contact at all stages. **Sil., Dev.**

PLATYCERAS *ss.* [= ACROCULIA Phillips 1841; ACTITA Fahrenkohl 1844]. Whorls coiled in contact in early growth stages but free and horn-shaped at later stages. **Sil.–Miss., Perm.?**

ORTHONYCHIA Hall 1843 [= IGOCERAS Hall 1860; PALAEOCAPULUS Grabau and Shimer 1909; GERONTICERAS Grabau 1936] (**Platyceras* (*Orthonychia*) *subrectum* Hall). Whorls free and horn-shaped at all stages of growth. **Sil.?, Dev.–Perm.**

P. (**Platyostoma**) **cornutum** (Kindle and Breger) (= "**Diaphorostoma niagarense** (Hall)") (**193**—1, 2). **Sil.:** Mississippi Valley.

P. (**Platyceras**) **niagarense** (Hall) (**193**—10). Same as preceding.

P. (***Platyostoma**) **ventricosum** Conrad (**193**—3, 4). **Dev.** (Helderberg, Oriskany): Eastern U. S. A.

P. (**Platyceras**) **unguiforme** Hall (**193**—5–7). **Dev.** (Helderberg): Eastern U. S. A.

P. (**Platyceras**) **dumosum** Conrad (**193**—15, 16). **Dev.** (Onondaga): Eastern U. S. A., Mississippi Valley.

P. (***Orthonychia**) **subrectum** Hall (**193**—19) **Dev.** (Onondaga): Eastern U. S. A.

P. (**Platyostoma**) **turbinatum** (Hall) (**193**—13, 14). **Dev.** (Onondaga): Eastern U. S. A.

P. (**Orthonychia**) **conicum** (Hall) (**193**—17). **Dev.** (Onondaga, Hamilton): Canada; eastern and central U. S. A.

P. (**Platyceras**) **haliotoides** Meek and Worthen (**193**—9). **Miss.** (Kinderhook): Mississippi Valley.

P. (**Orthonychia**) **tribulosum** White (**193**—8). **Miss.** (Osage): Mississippi Valley.

P. (**Orthonychia**) **quincyense** (McChesney) (**193**—18). Same as preceding.

P. (**Orthonychia**) **parvum** (Swallow) (**193**—11, 12). **Penn.:** Mississippi Valley.

PRAENATICA Perner 1907

(= PROSIGARETUS Perner 1907)

(**Strophostylus gregarius proeva*). Naticiform to haliotiform shells with shape similar to that of living *Haliotis* or *Sigaretus*; no fold on columellar lip; ornamentation, growth lines, often wavy. **Sil., Dev.** (widespread).

P. expansa (Hall) (**194**—36). **Dev.** (Oriskany): Eastern U. S. A.

PTYCHOSPIRINA Perner 1907

(= PTYCHOSPIRA Perner 1907)

(**Holopea mima*). Naticiform to turbinate shells very similar to *Platyceras* (*Platyostoma*), but with apertural margins complete and unbroken and aperture obliquely elongated; occasional irregularities of growth attest a habit of fixation; ornamentation, usually transverse lirae or growth lines. **Dev.** (widespread).

PLATE 194

[Figures are x1 and original by Knight unless otherwise indicated.]

1, 2. Turbonopsis shumardi. Side and apertural views of holotype. **3–5. Ptychospirina varians** [Pal N Y 5 (2)]. Apertural, basal, and side views of three different shells, the last showing injury to peristome during growth. **6, 7. Naticonema lineata** [Pal N Y 5 (2)]. Apertural and side views. **8–12. Strophostylus** spp. **8–11. S. girtyi.** Top view; apertural view (x2); anterior view showing sinus in lip (x2); top view (x2). **12. S. andrewsi** [Pal N Y 3]. Apertural view. **13, 14. Poleumita** spp [N Y St Mus, M 5]. **13. P. crenulata. 14. P. scamnata. 15–24. Naticopsis** spp. **15, 16. N. carleyana** [AMNH, B 1 (3)]. **17–19. N. ventricosa.** Two views of a large specimen; side view of a smaller, more slender specimen. **20, 21. N. subovata.** Apertural view of a small specimen; side view of a broken specimen, partly restored. **22, 23. N. scintilla.** Side views of two specimens. **24. N. transversa.** Side view showing a little of the aperture (x6). **25–35. Trachydomia** spp. **25, 26. T. sayrei.** Apertural and side views (x2). **27, 28. T. oweni.** Side and apertural views (x2). **29, 30. T. nodulosa.** Side and apertural views (x2). **31, 32. T. newelli.** Side and apertural views. **33–35. T. nodosa.** Side view of small specimen; apertural and side views of large specimen. **36. Praenatica expansa** [Pal N Y 3]. Top view.

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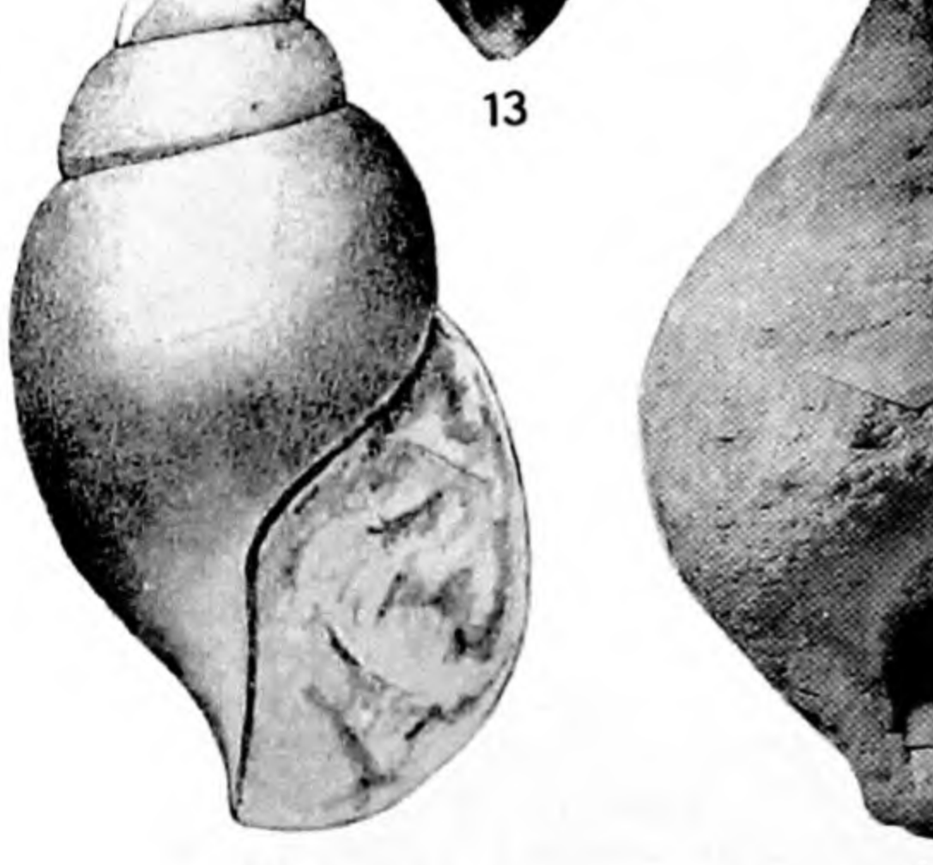

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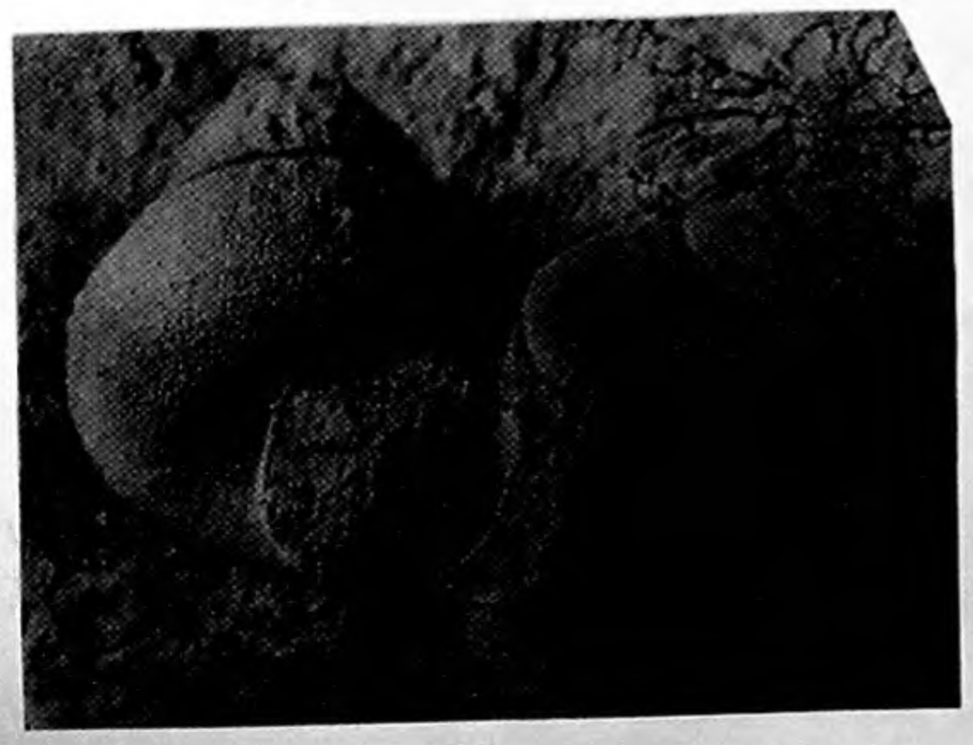

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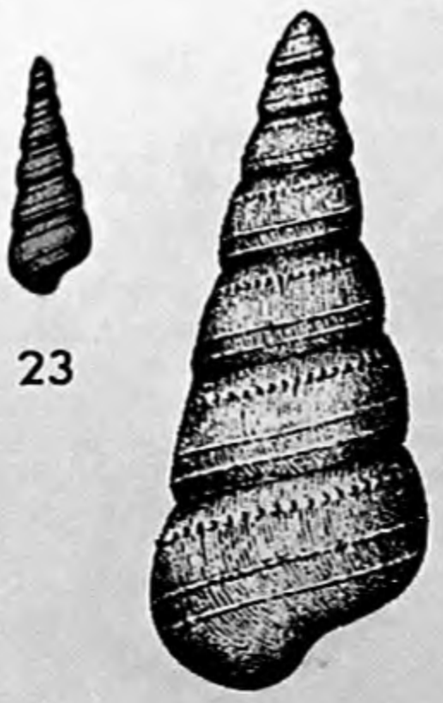

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P. varians (Hall) (**194**—3–5). **Onondaga:** Eastern U. S. A.

NATICONEMA Perner 1903

(= OTOSPIRA Perner 1903)

(**N. similare*). Naticiform shells similar to *Platyceras* (*Platyostoma*), but with columellar lip flattened and excavated; ornamentation, fine revolving lirae and growth lines. **Sil., Dev.** (widespread).

N. lineata (Conrad) (**194**—6, 7). **Dev.** (Onondaga, Hamilton): Eastern U. S. A.

STROPHOSTYLUS Hall 1859

(= HELICTOSTYLUS Knight 1934)

(**S. andrewsi*). Naticiform shells similar to *Platyceras* (*Platyostoma*) with large body whorl and a platelike fold on columella; ornamentation, transverse growth lines. **Dev.–Penn.** (N. America).

***S. andrewsi** Hall (**194**—12). **Dev.** (Oriskany): Eastern U. S. A.

S. girtyi (Knight) (**194**—8–11). **Penn.** (Virgil): Mississippi Valley.

POLEUMITA Clarke and Ruedemann 1903

(= POLYTROPIS Koninck 1881; MORPHOTROPIS Perner 1903; RHABDOSPIRA Perner 1903; CYCLOTROPIS Perner 1903; POLYTROPINA Donald 1905; EUCYCLOTROPIS Cossmann 1909; BERAUNIA Knight 1937)

(**Euomphalus discors* Sowerby). Discoidal to turbinate shells with wide umbilicus and rounded or shouldered whorls; outer lip oblique without sinus but in some species convex above and concave below; operculum multispiral and calcareous; ornamentation, revolving angulations, carinae or costae, and transverse often fasciculate or lamellose growth lines, usually notched where they cross revolving elements. **Sil.–L. Dev.** (widespread).

P. scamnata Clarke and Ruedemann (**194**—14). **Niagaran:** Mississippi Valley.

P. crenulata (Whiteaves) (**194**—13). **Niagaran:** Canada; Mississippi Valley.

NATICOPSIS McCoy 1844

(= NATICODON Ryckholt 1847; CATINELLA Stache 1877; PLAYTOSTOMELLA Etheridge, Jr., 1880; NERITOMOPSIS Waagen 1880)

(**N. phillipsii*). Neritiform to naticiform shells with large final whorl and nearly straight but oblique outer lip; base without umbilicus; parietal inductura thickened and in most species extended and flattened in plane of aperture, sometimes striated; ornamentation, growth lines alone, often fasciculate just below upper suture; operculum calcareous, nonspiral. **Dev.–Perm., Trias.?**

N. carleyana (Hall) (**194**—15, 16). **Miss.** (Salem): Mississippi Valley.

N. ventricosa (Norwood and Pratten) (**194**—17–19). **Penn.** (L. Des Moines): Mississippi Valley.

N. scintilla Girty (**194**—22, 23). **Penn.** (Missouri): Mississippi Valley.

N. subovata Worthen (**194**—20, 21). Same as preceding.

N. transversa (Beede) (**194**—24). **Perm.** (Guadalupian): Southwestern U. S. A.

TRACHYDOMIA Meek and Worthen 1866

(**Naticopsis nodosa*). Neritiform shells with large final whorl and nearly straight but oblique outer lip; base without umbilicus; parietal inductura thickened, extended and flattened in plane of aperture; ornamentation, pustules often quincuncially arranged. **Penn., Perm.** (widespread).

T. oweni Knight (**194**—27, 28). **L. Des Moines:** Mississippi Valley.

***T. nodosa** (M and W) (**194**—33–35). **U. Des Moines:** Mississippi Valley.

T. sayrei Knight (**194**—25, 26). **U. Missouri:** Mississippi Valley.

T. newelli Knight (**194**—31, 32). Same as preceding.

T. nodulosa Worthen (**194**—29, 30). **Missouri:** Mississippi Valley.

Order Mesogastropoda

ORTHONEMA Meek and Worthen 1862

(**Eunema? salteri*). High spired shells with outer lip nearly straight but with tendency to turn forward near upper suture; nucleus smooth, orthostrophic; base round or flattened, without umbilicus; ornamentation, revolving costae, commonly divided in pairs on upper and lower whorl faces. **Penn., Perm.** (widespread).

***O. salteri** (M and W) (**195**—1). **Penn.** (Des Moines): Mississippi Valley.

O. conicum (Meek and Worthen) (**195**—2). Same as preceding.

PLATE 195

[Figures are xl and original by Knight unless otherwise indicated.]

1–5. Orthonema spp. 1. O. salteri. Apertural view of holotype (x6). **2. O. conicum.** Side view (x4). **3, 4. O. marvinwelleri.** Two broken specimens (x8). **5. O. schucherti.** Side view (x4). **6–10. Meekospira spp. 6–8. M. planilateralis** [Ohio G S 7]. Apertural views (x1, x2) and side view. **9. M. minuta** [Walker Mus (Chicago), Contr 1]. **10. M. subconica** [Minn G S 3 (2)]. **11–15. Girtyspira spp. 11, 12. G. pygmaea** [Walker Mus (Chicago), Contr 1]. **13, 14. G. minuta.** Apertural views of a specimen without shouldering and one with strong shouldering (x10). **15. G. canaliculata.** Apertural view (x10). **16–19. Subulites spp. 16. S. (Cyrtospira) tortilis.** Apertural view (x2). **17. S. (Subulites) terebreviformis** [Ohio G S 2 (2)]. **18. S. (Fusispira) subbrevis** [Minn G S 3 (2)]. **19. S. (Fusispira) inflatus. 20. Meekospira peracuta.** Apertural view (x2). **21. Subulites (Cyrtospira) ventricosus** [N Y St Cab N H, Rp 20]. **22–24. Acanthonema newberryi.** Two specimens (x6), the left being the holotype and showing an oblique basal view; a complete specimen (x1, x3) [Pal Ohio 1]. **25–27. Subulites spp. 25. S. (Subulites) nanus** [Minn G S 3 (2)]. **26. S. (Subulites) subelongatus.** Apertural view (x2). **27. S. (Subulites) regularis** [Minn G S 3 (2)].

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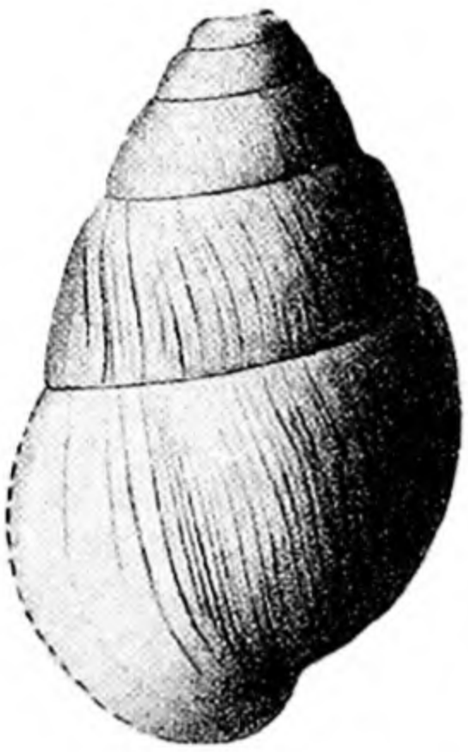

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O. marvinwelleri Knight (**195**—3, 4). Same as preceding.

O. schucherti Knight (**195**—5). **Penn.** (Virgil): Mississippi Valley.

ACANTHONEMA Sherzer and Grabau 1908

(**A. holopiforme* = *Bellerophon newberryi* Meek). High spired shells with nearly straight outer lip; nucleus smooth, orthostrophic; base rounded, seemingly with minute umbilicus; ornamentation, one or more revolving ridges, one or more nodose. **Dev.** (N. America).

***A. newberryi** (Meek) (**195**—22–24). **M. Dev.:** Canada; northern Misssisippi Valley.

MEEKOSPIRA Ulrich and Scofield 1897

(**Eulima? peracuta* Meek and Worthen). High spired shells with straight outer lip and without columellar fold or siphonal channel; columellar lip moderately arcuate, reflexed, the reflexed portion continuous with parietal inductura, which passes out of sight within aperture before covering parietal wall; base roundly tapering, without an umbilicus; ornamentation, fine growth lines. **Ord.–Perm.** (widespread).

M. subconica Ulrich and Scofield (**195**—10). **Ord.** (Richmond): Mississippi Valley.

M. planilateralis (Foerste) (**195**—6–8). **Sil.** (Medinan): Mississippi Valley.

M. minuta Weller (**195**—9). **Miss.** (Ste. Genevieve): Mississippi Valley.

***M. peracuta** (M and W) (**195**—20). **Penn.** (Des Moines): Mississippi Valley.

GIRTYSPIRA Knight 1936

(**Bulimella canaliculata* Hall). Small fusiform shells with straight outer lip and without columellar fold or siphonal channel; columellar lip arcuate, reflexed, the reflexed portion continuous with parietal inductura, which passes out of sight within aperture before covering parietal wall; base markedly tapering; whorls typically shouldered but this feature variable even within species; ornamentation, fine growth lines. **Miss., Penn.** (widespread).

***G. canaliculata** (Hall) (**195**—15). **Miss.** (Salem): Mississippi Valley.

G. pygmaea (Weller) (**195**—11, 12). **Miss.** (Ste. Genevieve): Mississippi Valley.

G. minuta (Stevens) (**195**—13, 14). **Penn.** (Des Moines): Mississippi Valley.

Order Neogastropoda

SUBULITES Emmons 1842

(= POLYPHEMOPSIS Portlock 1843)

(**S. elongatus*). Fusiform shells with moderately high spire and siphonal channel at base of columella; aperture elongate; whorls high, deeply embracing; base tapering, without umbilicus; parietal inductura complete but thin; ornamentation, fine growth lines. **Ord., Sil.** (widespread).

This genus has many species, especially in the Ordovician, and for convenience they are divided into the following three artificial and intergrading groups, which are treated as subgenera.

SUBULITES *ss*. Spire high, straight; whorls high, flat; aperture very narrow.

CYRTOSPIRA Ulrich and Scofield 1897 (**C. tortilis*). Similar to *Subulites ss* but with curved spire.

FUSISPIRA Hall 1872 (**F. ventricosa*). Similar to *Subulites ss* but with more inflated whorls and wider aperture.

S. (*Cyrtospira) tortilis (U and S) (**195**—16). **Stones River:** Mississippi Valley.

S. (Subulites) regularis Ulrich and Scofield (**195**—27). **Black River:** Canada; Mississippi Valley.

S. (Subulites) nanus Ulrich and Scofield (**195**—25). **Black River:** Mississippi Valley.

S. (*Subulites) subelongatus (Orbigny) [=**S. elongatus** Emmons] (**195**—26). **Trenton:** Canada; eastern U. S. A.

S. (Fusispira) inflatus (Meek and Worthen) [= ***S. ventricosus** (Hall) 1871, not **S. ventricosus** (Hall) 1867] (**195**—19). **Trenton:** Eastern and central U. S. A.

S. (Fusispira) subbrevis (Ulrich and Scofield) (**195**—18). **Trenton:** Mississippi Valley.

S. (Subulites) terebreviformis Hall and Whitfield (**195**—17). **Niagaran:** Mississippi Valley.

S. (Cyrtospira) ventricosus Hall [not **S. ventricosus** (Hall) 1871]. (**195**—21). **Niagaran:** Canada: Mississippi Valley.

CERAUNOCOCHLIS Knight 1931

(**C. fulminula*). Small, cigar-shaped shells with high spire and high, flat whorls; sutures, except in nucleus, extremely shallow; aperture relatively short and with siphonal channel at base of columella; base tapering, without an umbilicus; parietal inductura complete, thin; ornamentation, fine growth lines. **Miss., Penn.** (N. America).

C. harrodsburgensis (Cumings) (**196**—3, 4). **Miss.** (Salem): Mississippi Valley.

PLATE 196

[Figures are x1 and original by Knight unless otherwise indicated.]

1–4. Ceraunocochlis spp. 1, 2. C. fulminula. Apertural views of holotype and a paratype (x15). **3, 4. C. harrodsburgensis** [Ind G S 30]. Anterior and posterior views. **5, 6. Bulimorpha bulimiformis.** Apertural view (x10); the holotype (x6). **7. Cylindritopsis vaningeni.** Apertural view (x6). **8–14. Strobeus spp. 8. S. subcostatus** [CGS, Contr Can Pal 1 (4)]. **9. S. paludinaeformis.** Apertural view of a specimen with outer lip broken back (x2). **10, 11. S. primogenius.** Apertural views (x2, x1) of two specimens with outer lip broken away. **12. S. regularis.** Specimen with aperture crushed. **13. S. littonanus** [AMNH, B 1 (3)]. **14. S. medialis.** Apertural view of a specimen with outer lip broken back. **15, 16. Soleniscus typicus** (x4). Complete specimen; the holotype, which has a broken aperture. **17–19. Leptoptygma spp. 17, 18. L. simplex.** Apertural views of two specimens (x4, x2). **19. L. virgatum.** Apertural view of holotype (x6), which has outer lip broken back.

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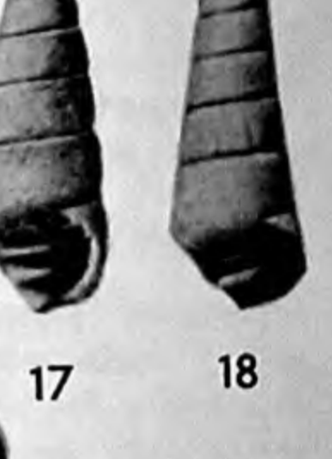
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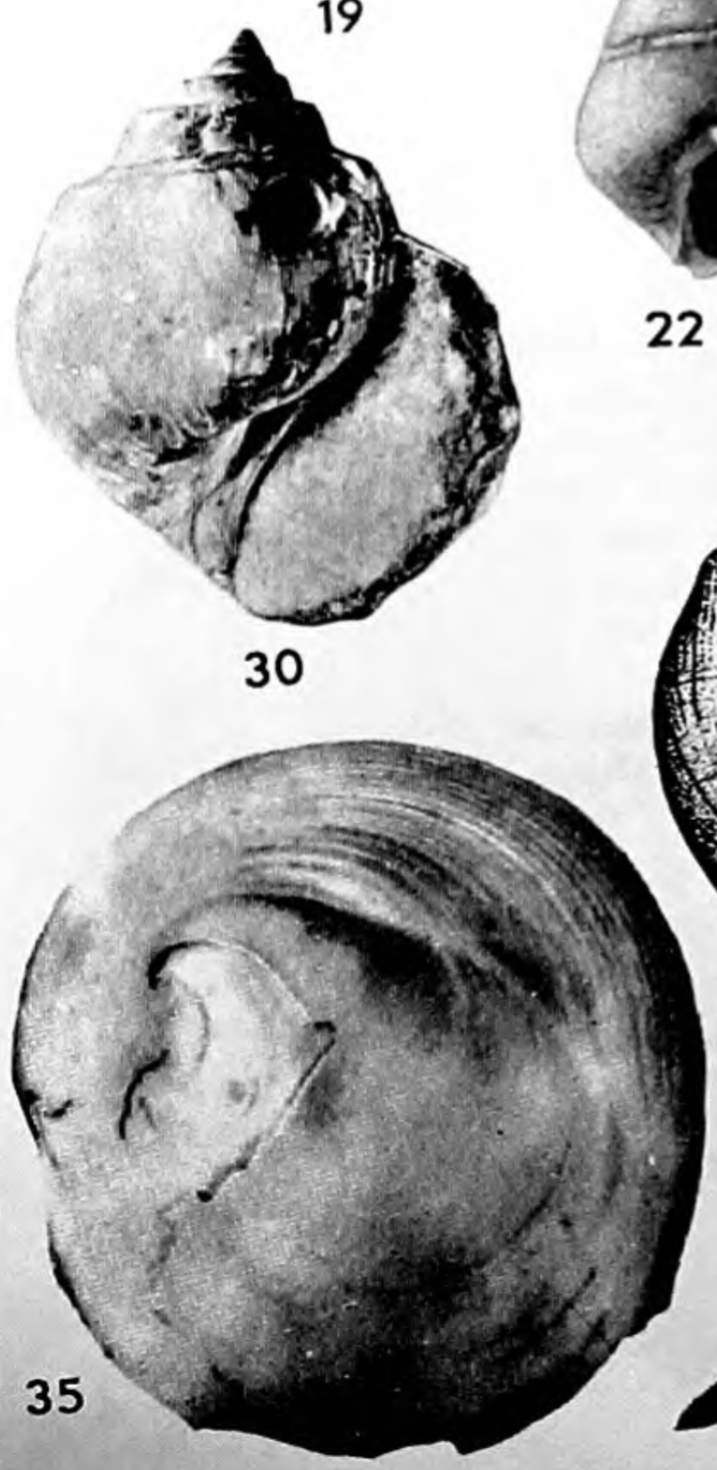
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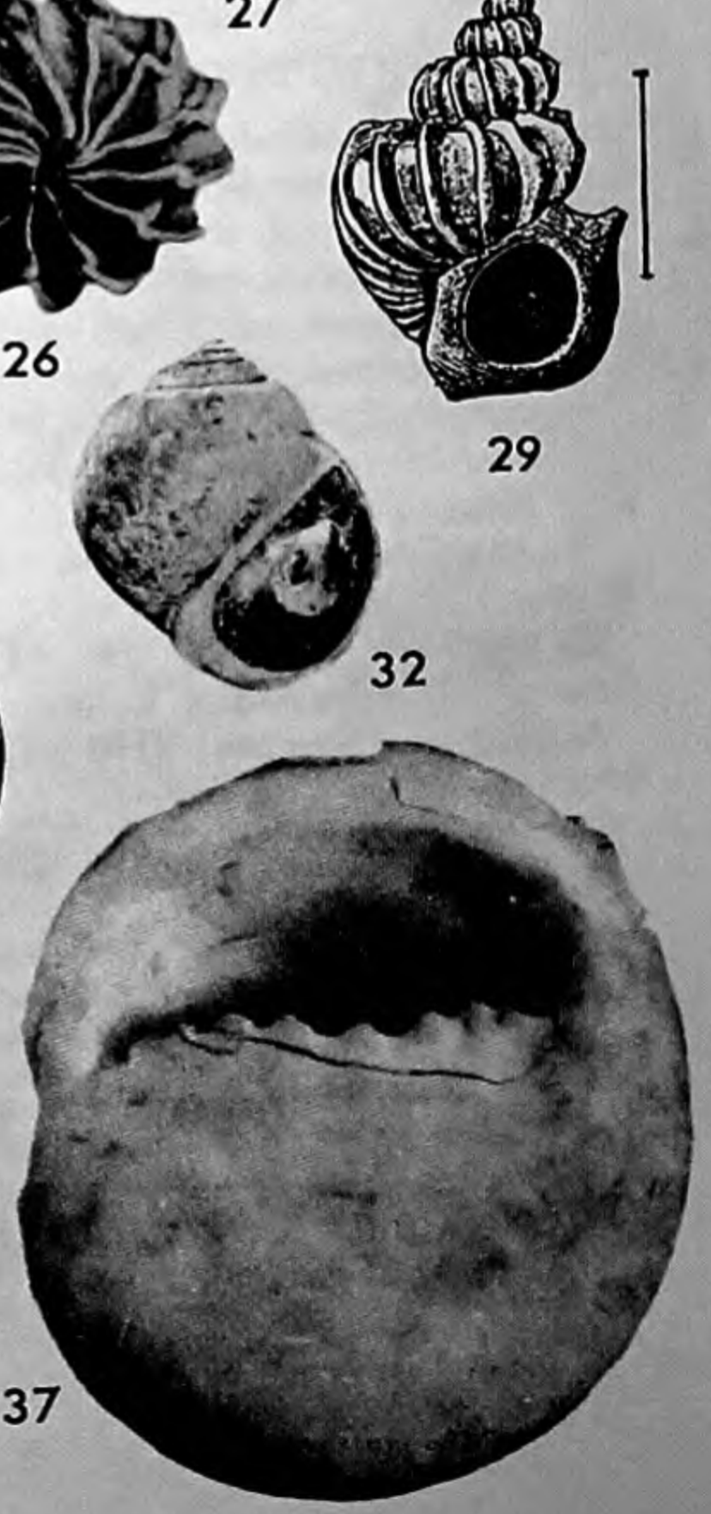
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***C. fulminula** Knight (**196**—1, 2). **Penn.** (Des Moines): Mississippi Valley.

BULIMORPHA Whitfield 1882

(= BULIMELLA Hall 1858)

(**Bulimella bulimiformis* Hall). Fusiform shells with moderately high spire and siphonal channel at base of columella; columella highly arcuate, with small siphonal fold near its base; parietal inductura seemingly wanting; aperture ovate; base tapering, without umbilicus; ornamentation, fine growth lines. **Miss.** (N. America).

***B. bulimiformis** (Hall) (**196**—5, 6). **Salem:** Mississippi Valley.

SOLENISCUS Meek and Worthen 1861

(= MACROCHEILUS Phillips 1841; DUNCANIA Bayle 1879; MACROCHILINA Bayle 1880)

(**S. typicus*). Fusiform shells with moderately high spire and siphonal channel at base of columella; inductura seemingly confined to lower part of inner lip and bearing two folds which are visible only when aperture is broken; lower (siphonal) fold obscure and near base while upper fold close above it is more strongly developed; base tapering, without umbilicus; ornamentation, fine growth lines. **Miss.–Perm.** (widespread).

***S. typicus** M and W (**196**—15, 16). **Penn.** (Des Moines): Mississippi Valley.

CYLINDROTOPSIS Gemmellaro 1889

(**C. ovalis*). Fusiform to globular shells with well marked siphonal channel at base of columella; inductura complete and bearing two conspicuous folds; base tapering, without umbilicus; ornamentation, fine growth lines. **Penn., Perm.** (widespread)

C. vaningeni (Knight) (**196**—7). **Penn.** (Des Moines): Mississippi Valley.

STROBEUS Koninck 1881

(= PLECTOSTYLUS Conrad 1842; SPHAERODOMA Keyes 1889)

(**S. ventricosus*). Fusiform to globular shells with broad siphonal channel at base of columella; inductura complete with more or less strongly developed siphonal fold on columella, best seen when aperture is broken, and more or less thickened on parietal wall; base tapering or rounded, without umbilicus; shell much thickened by internal secondary shell matter; ornamentation, fine growth lines. **Dev.–Perm.** (widespread).

The numerous species of this genus, especially common in the Pennsylvanian, have been variously, though erroneously, known under the generic names *Soleniscus*, *Macrocheilus*, *Macrochilina*, *Sphaerodoma*, and others.

S. subcostatus (Schlotheim) (**196**—8). **Dev.** (Stringocephalus zone): Canada.

S. littonanus (Hall) (**196**—13). **Miss.** (Salem): Mississippi Valley.

S. primogenius (Conrad) (**196**—10, 11). **Penn.:** Mississippi Valley.

S. paludinaeformis (Hall) (**196**—9). Same as preceding.

S. regularis (Cox) (**196**—12). Same as preceding.

S. medialis (Meek and Worthen) (**196**—14). Same as preceding.

LEPTOPTYGMA Knight 1936

(**Auriptygma virgatum*). Fusiform to subglobular shells with very low, obscure fold on columella and with broad, shallow channel below; inductura incomplete, the parietal wall being uncovered except close to columella; base tapering or rounded, without umbilicus; ornamentation, fine growth lines or transverse lirae. **Penn.** (N. America).

***L. virgatum** (Knight) (**196**—19). **Des Moines:** Mississippi Valley.

L. simplex (Knight) (**196**—17, 18). Same as preceding.

MESOZOIC TO RECENT GASTROPODA

Superorder **Prosobranchia**

VELATES Montfort 1810

(**Nerita perversa* Gmelin = *V. conoideus* = *V. schmidelianus* of authors). Differs from *Nerita* and *Neritina* (neither discussed here) mainly in peculiar growth of large, flat callus. **Cret.; Eoc.** (worldwide distribution.)

[1] We take pleasure in acknowledging the valuable aid of the following, who helped us many times in various ways: Drs. W. J. Clench, Julia A. Gardner, R. W. Imlay, J. B. Reeside, Jr., L. W. Stephenson, R. B. Stewart, and W. P. Woodring.

PLATE 197

[Figures are x1 unless otherwise indicated.]

1. Urceolabrum tuberculatum (x7) [USGS, PP 137]. **2, 3. Calliostoma** spp. **2. C. (Calliostoma) philanthropus** (x1.3), [Md G S, Mioc]. **3. C. canaliculatum** [San Diego Soc N H, M 1]. **4, 5. Schizobasis depressa** [USGS, PP 137]. Type. **6–10. Margarites** spp. **6. M. (Periaulax) mudgeana** [USGS Ter 9]. Replica of exterior surface. **7–9. M. (Margarites) abyssina** [Pal N J 2]. Lateral views of a specimen (x1, x2) and basal view of same. **10. M. (Atira) ornatissima** (x2) [Pal Cal 1]. **11, 12. Diodora (Diodora) griscomi** [Md G S, Mioc]. Side and top views. **13. Diodora aspera** [Stanford U Pub G 2 (3)]. Type. **14–16. Turbonilla** spp. **14. T. nivea** [Md G S, Mioc]. **15. T. interrupta** [Md G S, Mioc]. **16. T. coalvillensis** [USGS, B 106]. **17, 18. Creonella triplicata** (x4) [USGS, PP 137]. Views of two shells; 18 is the type. **19, 20. Hallotis lasia** [USNM, Pr 81]. Type and a paratype. **21–23. Odostomia** spp. **21. O. conoidea** (x6) [Md G S, Mioc]. **22, 23. O. impressa** [USGS, PP 137]. Two views of type (x6). **24–29. Epitonium** spp. **24, 25. E. (Nitidiscala) tinctum** [San Diego Soc N H, Tr 6]. Two views of a shell (x3). **26, 27. E. sillimani** [USGS, PP 137]. Basal and apertural views (x2). **28. E. sayanum** [Md G S, Mioc]. **29. E. (Sthenorytis) pachypleura** [Md G S, Mioc]. **30. Amaurellina moragai lajollaensis** (x1.3) [Ac N Sc Phila, Pr 78]. **31, 32. Ampullina** spp. **31. A. (Ampullinopsis) mississippiensis** [Ac N Sc Phila, J (2) 1]. **32. A. avellana** (x1.5) [Ac N Sc Phila, Pr 78]. **33, 34. Amauropsis bulbiformis** (x0.7) [USGS, B 106]. **35–37. Velates perversus** [U Cal Pub g s 23 (12)]. Views of three specimens from France.

***V. perversus** (Gmelin) (**197**—35–37). Shape extremely variable; inner lip with seven to eight small teeth, unequally arranged; basal callosity large. **Eoc.** (An index fossil of the Eocene throughout the Tethys area — Europe, Africa, Asia): West Indies (St. Bartholomew); Cal. (Domengine, Llajas).

CALLIOSTOMA Swainson 1840

(**Trochus conulus* Linnaeus). Trochoid shell, with abrupt basal deflection, peripheral keel and flattened shoulders; surface with ribs or spirals; CALLIOSTOMA *ss* has first whorls with beaded spiral ridges, later ones smooth or with spiral furrows **U. Cret.–Recent.** (worldwide distribution as fossils, and in all present seas).

C. (**Calliostoma**) **philanthropus** (Conrad) (**197**—2). Peripheral keel pronounced, upper spirals beaded or nodulated; some varieties have three beaded spirals with sometimes intercalated smaller smoother ones. **Mioc.** (Chesapeake): Md., Va., N. C.

C. canaliculatum (Martyn) (**197**—3). Distinguished by its large size, prominent spiral riblets, and flattened base; **C. costatum** (Martyn), with essentially similar distribution, has much heavier shell, rounded body whorl, and is smaller. **Plioc.:** Cal.; **Pleist.:** Cal.; L. Cal., Mex.; **Recent:** Sitka, Alaska, to San Diego, Cal.

URCEOLABRUM Wade 1916

(**U. tuberculatum*). Shell small, trochoid, spire elevated; sculpture cancellate; suture impressed; aperture circular and much thickened around rim; umbilicus wide and deep. **U. Cret.** (Tenn., Ala.; Germany).

***U. tuberculatum** Wade (**197**—1). **Ripley:** Tenn.

SCHIZOBASIS Wade 1916

(**S. depressa*). Spire depressed; peculiar anterior canal, which is short and deep and perpendicular to shell axis, resembling a slit in anterior part of aperture. **U. Cret.** (Tenn., Ala.).

***S. depressa** Wade (**197**—4, 5). **Ripley:** Tenn.

MARGARITES Gray 1847

(= MARGARITA Leach 1819 *non* 1814; EUMARGARITA Fischer 1885)

(**Turbo helicina* Fabricius = *Helix margarita* Montagu). "Form genus" including trochoid, umbilicated shells with rounded whorls and impressed suture; umbilicus broad; several subgenera recognized.

MARGARITES *ss* (= VALVATELLA Smith 1899 *non* Gray 1857). Shell generally broader than high; embryonic spiral small, flattened; whorls separated by linelike sutures, smooth or with fine sculpture; last whorl large, rounded; umbilicus generally broad, not bounded by a ridge; aperture large, circular; outer lip sharp. **U. Cret.** (N. America)–**Recent.**

PERIAULAX Cossmann 1886. Shell similar to *Margarites ss*, nearly as high as broad; whorls with distinct spiral and growth lines; umbilicus bounded by furrow and ring and internally sculptured; axial rim somewhat thickened, not folded over. **U. Cret.–Plioc.** (N. America; Europe; East Africa; India).

ATIRA Stewart 1927. Shell similar to *Margarites ss*; whorls with fine spiral and growth lines; umbilicus bounded by single ridge. **U. Cret.** (N. America).

PUPILLARIA Dall 1909. **Mioc.** (N. America; Iceland)– **Recent.**

M. (**Margarites**) **abyssina** (Gabb) (**197**—7–9). Whorls four or more; apical angle 70° to 75°; shell thin, with very fine spirals, and apparently a stronger peripheral one. **U. Cret.** (Matawan, Monmouth): N. J., Md.

M. (**Atira**) **ornatissima** (Gabb) (**197**—10). **U. Cret.:** B. C. (Nanaimo of Vancouver Island); Cal. (Chico).

M. (**Periaulax**) **mudgeana** (Meek) (**197**—6). Turbinate; four and a half to five whorls, last somewhat obliquely flattened above and below and laterally compressed or flattened around middle of outer side, at base of which it is angular; suture channeled; aperture circular, outer lip thin and oblique; columella arched and flattened below; sculpture consisting of growth lines crossed by four equidistant, rather sharp revolving carinae, only three of which are visible on volutions of spire. **Cret.:** Kan. (Dakota).

DIODORA Gray 1821

(= FISSURIDEA Swainson 1840; GLYPHIS Carpenter 1857; CAPILUNA Gray 1857; ?MONODILEPAS Finlay 1927)

(**Patella? graeca* Linnaeus = *Patella apertura* Montagu). Shell subconical or subcapuliform, with oval base; apex anterior to middle and replaced by perforation with callus of interior; surface bearing radial ridges and concentric folds. **Cret.–Recent** (worldwide distribution).

D. (**Diodora**) **griscomi** (Conrad) (**197**—11, 12) and **D.** (**Diodora**) **marylandica** (Conrad). **Mioc.** (Chesapeake): Atlantic Coast.

D. aspera (Eschscholtz in Rathke) (**197**—13). **Pleist.:** Cal.; L. Cal., Mex.; **Recent:** Cook's Inlet, Alaska, to L. Cal., Mex.

HALIOTIS Linnaeus 1758

(**H. asininus*). Generic characters illustrated by species. **Cret.?, Olig.–Recent** (worldwide, but like other rock-clingers, almost never preserved).

H. lasia Woodring (**197**—19, 20). **U. Mioc.:** Cal.

CREONELLA Wade 1917

(**C. triplicata*). Characterized by three conspicuous folds on inner lip; most posterior of these situated on body of preceding whorl, other two on columella; former the stronger, and on each side of it is a deep columellar sulcus. **U. Cret.** (Tenn., Tex.)

***C. triplicata** Wade (**197**—17, 18). Characterized by its narrow, numerous whorls and its very sharp, strongly impressed suture. **Ripley:** Tenn.

TURBONILLA Risso 1826

(**T. typica* Dall and Bartsch = *T. plicatula* Risso, not *T. plicatulus* Scacchi). "Form genus" with numerous subgenera; shell with sinistral apex, cylindro-conic, many whorled; a single columnar fold which varies in strength; smooth or ribbed. **U. Cret.–Recent** (Atlantic and Pacific Coasts).

T. coalvillensis Meek (**197**—16). **Cret.:** Utah.

T. interrupta (Totten) (**197**—15). With narrow intercostal spaces occupied by interrupted spirals; spirals marked on base of body whorl. **Mioc.:** Md.

T. nivea Stimpson (**197**—14). Long and slender with regular rigid vertical ribs. **Mioc.?–Pleist.:** Md., Carolinas (**Pleist.**).

ODOSTOMIA Fleming 1813

(**Turbo plicatus* Montfort). Sutures depressed; columellar tooth; surface smooth or sculptured. **U. Cret.–Recent.**

O. impressa Wade (**197**—22, 23). Characterized by deeply impressed spiral line just in front of suture, two columellar plaits, and a lirate inner lip. **U. Cret.:** Tenn. (Ripley).

O. conoidea (Brocchi) (**197**—21). Small, short, with elongate body whorl; angle of young greater than adult. **Mioc.:** Md. (St. Marys?, Choptank), N. J. (Calvert).

EPITONIUM "Bolten" Roeding 1798

(= SCALA Bruguière 1792; SCALARIA Lamarck 1801) (**Turbo scalaris* Linnaeus = *Scalaria pretiosa* Lamarck). Turreted, nonumbilicate shells with deep sutures and convex whorls, marked at regular and frequent intervals by smooth varices; many subgenera and species. **Trias.–Recent.**

E. sillimani (Morton) (**197**—26, 27). Broad spired and rather closely coiled, with very oblique sharp varices and very fine spirals; internal fillings smooth, with deep sutures. **U. Cret.** (Ripley): N. J., Tenn., Ala., Miss.

E. (**Sthenorytis**) **pachypleura** (Conrad) (**197**—29). Short and thick, with large body whorl; varices thick, subspinose above; body whorl with discontinuous spiral in interspaces; aperture nearly circular, lips expanded. **Mioc.:** Md.

E. sayanum (Dall) (**197**—28). Varices 7 to 11 per whorl, sharp and slightly oblique; interspaces smooth. **Mioc.:** ?Md. (St. Marys, Choptank); **Plioc.:** Fla. (Caloosahatchee); **Post-Plioc.:** S. C.; **Recent:** Va. to Key West to Tex.

E. (**Nitidiscala**) **tinctum** (Carpenter) (**197**—24, 25). **Plioc.:** Cal.; **Pleist.:** Cal.; L. Cal., Mex.; **Recent:** Vancouver Island, B. C., to L. Cal.

AMAURELLINA Fischer 1885

(**Natica spirata* Lamarck). Distinguished from *Ampullina* by its narrow umbilicus and high spire. **Eoc.**

A. moragai lajollaensis Stewart (= **Amauropsis alveata** Gabb) (**197**—30). **Eoc.:** Cal. (Domengine).

AMPULLINA Bowdich 1822

[Sherborn gives priority to AMPULLINA Férussac 1822]

(**A. depressa*). Shell medium-sized, umbilicated, with rather distinct shoulder and very finely punctate spiral lines; columella heavy, excavated, columellar lip nearly straight; a broad rugose area surrounding umbilicus and corresponding to siphonal fasciole. **Cret.–Recent** (worldwide distribution).

A. avellana (Gabb) (**197**—32). Subglobose, embracing to above ambitus, with impressed suture; moderate spire; large, minutely umbilicated body whorl; inner lip slightly callous, aperture acute above. **L. Cret.:** Cal. (Horsetown).

A. (**Ampullinopsis**) **mississippiensis** (Conrad) (**197**—31). Large; spire somewhat elevated; suture deeply canaliculate; body whorl somewhat depressed-convex; aperture ovoid; inner lip expanded over umbilical region. **Eoc.:** Gulf Coast (U. S. A. and Mex.).

AMAUROPSIS Moerch 1857

(**Natica helicoides* Johnston = *?Nerita islandica* Gmelin). High spired, nonumbilicate; sides of whorls more or less flattened; those of body whorl often parallel to axis; sutural flattening or shelf often nearly rectangular to sides. **L. Cret.–Recent** (species other than Tert. should probably not be referred to this genus).

"A". bulbiformis (Sowerby) (**197**—33, 34). Large; whorls moderately convex, slightly depressed below sutural angulation sutural shelf depressed or canaliculate, outer lip nearly vertical. **U. Cret.:** Colo. (Pugnellus, Benton); widely distributed in Europe and Asia.

SINUM "Bolten" Roeding 1798

(= SIGARETUS Lamarck 1799)

(**Helix haliotoides* Linnaeus). Broad spired, naticoid shell with rapidly enlarging whorls, distended aperture with horny operculum, and spiral surface structure. **U. Cret.–Recent** (Atlantic and Pacific Coasts of N. America).

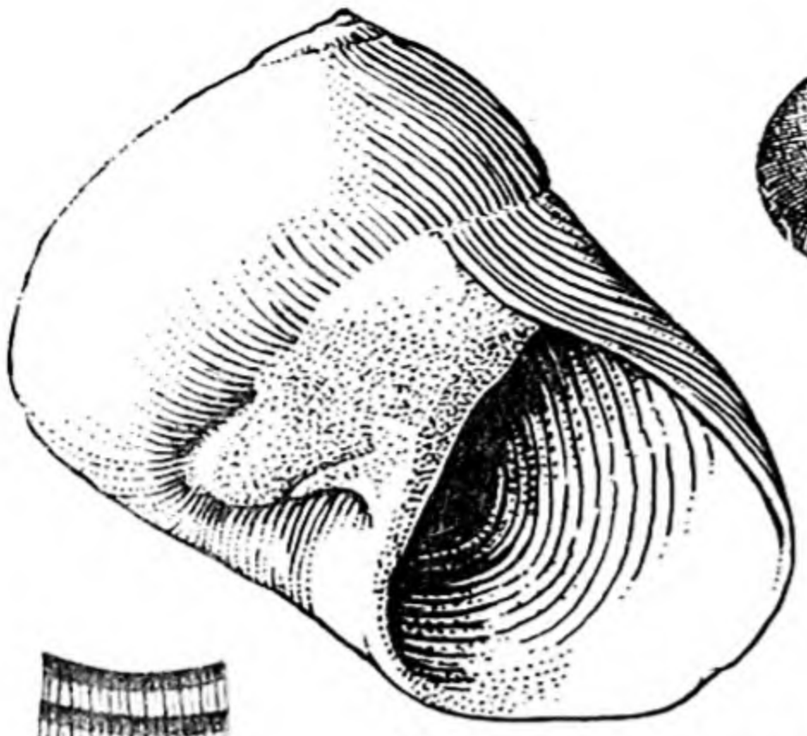
S. bilix (Conrad) (**198**—4). Rotund; umbilicus large; spirals crowded and in pairs. **Eoc.:** Ala. (Wilcox), Ala. and Tex. (Claiborne).

S. fragile (Conrad) (**198**—1, 2). Larger than preceding (22 mm high); aperture about four-fifths shell length; inner lip less prominent; umbilicus small; spirals uniform, crowded. **Mioc.:** Atlantic Coast of U. S. A.

S. scopulosum (Conrad) (**198**—3). **Mioc.:** Ore. (Empire), Cal. (San Ramon, San Pablo, Santa Margarita); **Plioc., Pleist.:** Cal.; **Recent:** Cal.; L. Cal., Mex.

NEVERITA Risso 1826

(**N. josephina* Risso = *N. olla* Serres). Shell naticoid, ovate; sutures tangential, appressed; apertural callus thick, coalescing with a huge funicle filling umbilicus; aperture greatly inclined. **Eoc.–Recent** (Atlantic and Pacific Coasts of N. America).



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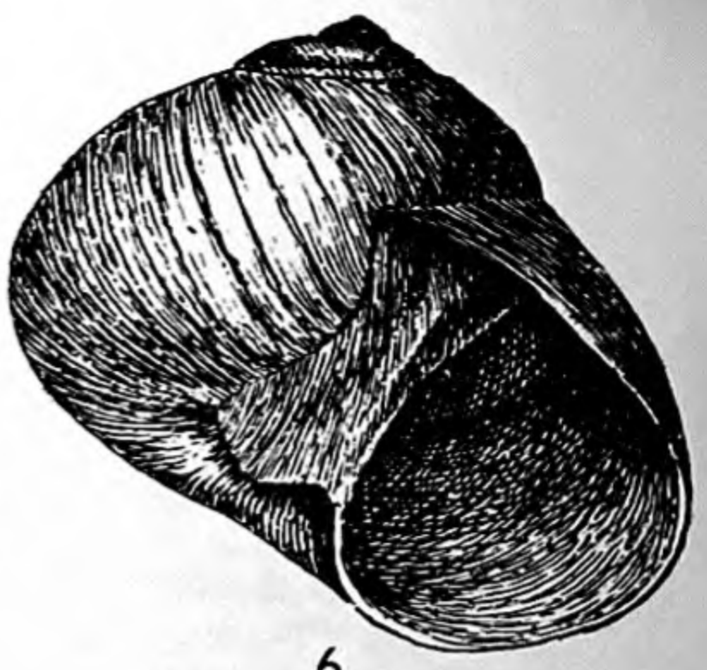

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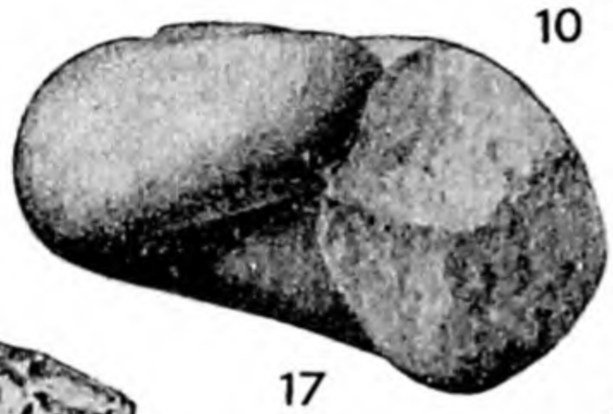

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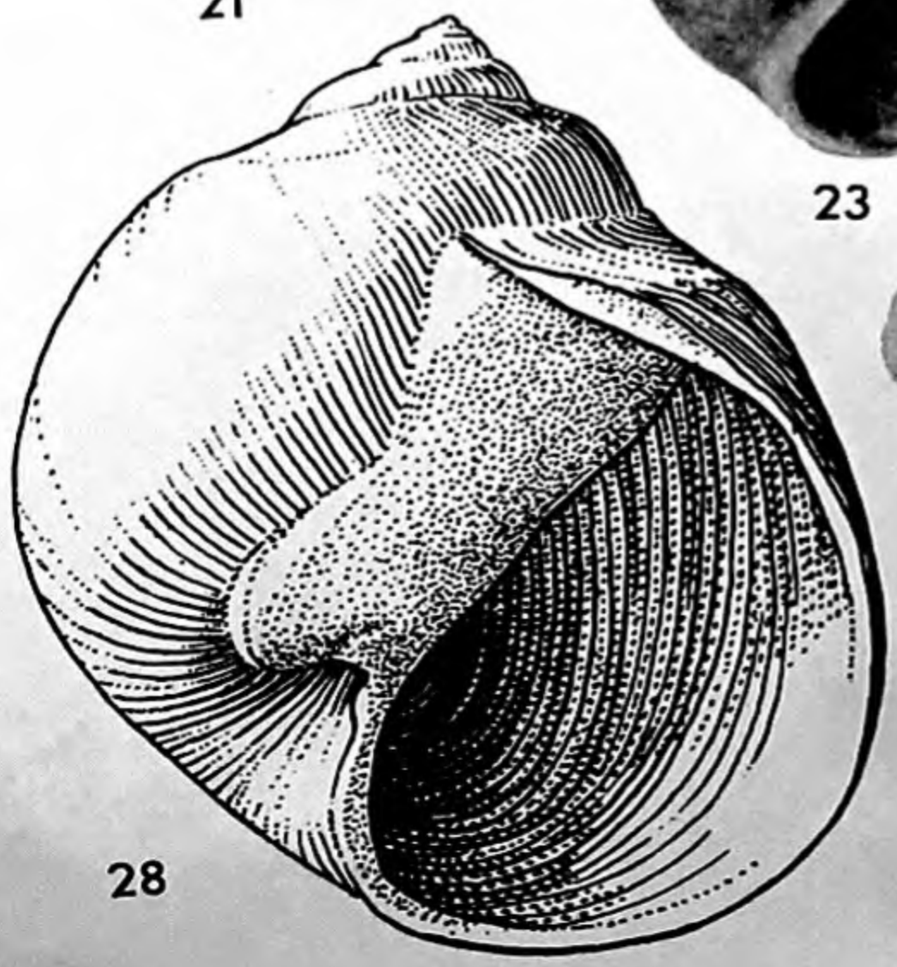

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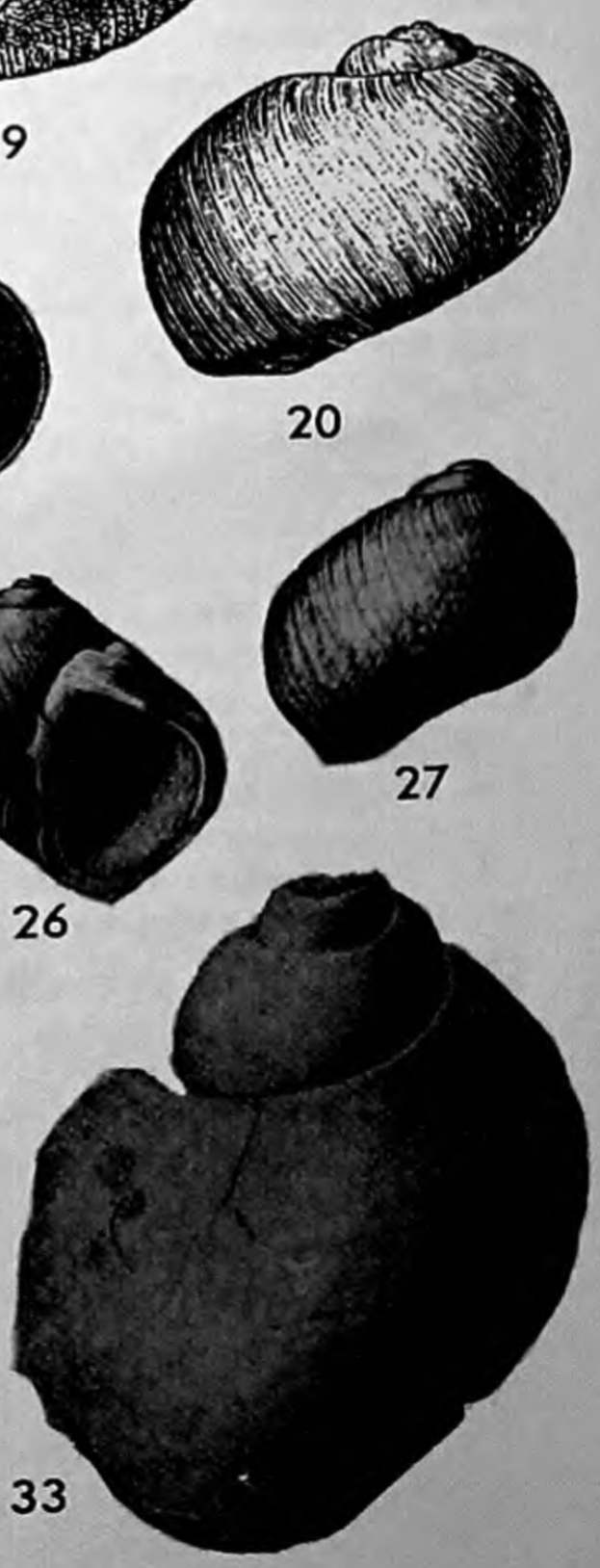

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N. duplicata Say (**198**—6). Strongly embracing whorls; spire with scarcely impressed sutures; callus of inner lip large, nearly or quite covering umbilicus. **Mioc.–Recent:** Chesapeake of Atlantic Coast; **Plioc.** of Atlantic and Gulf regions; **Pleist.** of Atlantic Coast and Md. southward; **Recent** from Mass. Bay southward.

N. reclusiana (Deshayes) (**198**—5). **Olig.–Recent:** Pacific Coast of N. America.

VANIKOROPSIS Meek 1876

(**Natica tuomeyana* Meek and Hayden). Practically nonumbilicate shells of naticoid form; inner lip thin, smooth, adhering to columella; surface with spirals and oblique riblike fold. **Cret.**

***V. tuomeyana** (M and H) (**198**—7, 8). Thick, few whorled, last whorl large, rounded; aperture ovate; faint umbilical indentation; spirals numerous; ribs on body whorl only. **U. Cret.** (Claggett and Bearpaw): Sask., Alta.; Mont.

V. suciensis White (**198**—9). Small, subovoid, with small spire and blunt apex; volutions four to five; body whorl much expanded, with large oval aperture; surface with fine spirals throughout. **U. Cret.:** B. C. (Nanaimo); Cal. (Chico).

GYRODES Conrad 1860

(**Natica* (*Gyrodes*) *crenata* Conrad). Naticoid shells with broad and deep umbilicus generally surrounded by an angulation, and a flattened or concave band at suture in later whorls; Eocene representatives referred to SIGARETOPSIS Cossmann 1888 (**Natica infundibulum* Wetelet). **Cret.** (N. America).

G. supraplicata (Conrad) (= ***G. crenatus** (Conrad)) (**198**—10–12). **U. Cret.** (Ripley): N. J., N. C., Tenn., Ga., Ala., Miss., Tex. (Navarro), Utah (Pierre).

G. abyssina (Morton) (**198**—16, 17). Like preceding but lacking basal carination. **U. Cret.:** Atlantic and Gulf Coasts (Ripley), Utah (Pierre).

G. petrosa (Morton) (**198**—13–15). Like preceding but smaller and with space below suture flat instead of concave. **U. Cret.:** Matawan, Monmouth of N. J., Md.; Ripley of Ala., Miss.; Navarro of Tex.

G. depressa Meek (**198**—20). Spire depressed or somewhat elevated; body whorl rapidly enlarging, subangular or narrowly rounded below, with large umbilicus; aperture ear-shaped. **U. Cret.** (Coloradoan): Colo., Utah.

G. conradi Meek (**198**—18, 19). Low spire, broadly rounded body whorl with subsutural angulation and narrowly flattened or concave band between this and suture, strongly carinate in central basal portion, while a further angulation margins the broad funnel-shaped umbilicus; aperture subrhombic, about twice as wide as high. **U. Cret.** (Coloradoan): S. Dak., Colo., Wyo.

G. conradiana Gabb. Like preceding, but without inner angulation around umbilicus. **U. Cret.:** B. C. (Vancouver); Wash. (Vancouver), Cal. (Chico).

G. expansa Gabb (**198**—21, 22). Whorls flattened at suture and flat or slightly concave below sutural angulation; basal portion without angulation. **U. Cret.** (Chico): Pacific Coast.

POLINICES Montfort 1810

(**P. albus* Montfort = *P. mamillaris* (Lamarck)). Naticoid; shell oval or suboval, solid, smooth; aperture semilunar, inner lip oblique, callous; callus extending into and more or less completely filling umbilicus; suture tangential; operculum corneous. **U. Cret.–Recent.**

P. shumardianus (Gabb) (**198**—25). **U. Cret.:** B. C. (Nanaimo); Cal. (Chico, Tejon).

P. (Euspira) halli (Gabb) (**198**—23, 24). Spire elevated, height about one and one-half times diameter; suture of internal fillings deep; umbilicus large; aperture acute above, acutely rounded below. **U. Cret.:** Matawan, Monmouth of N. J. and Md.; Ripley of Tenn.

TYLOSTOMA Sharpe 1849

(**T. torrubiae*). Shell ovate or globose, thick, smooth, with varices (remains of former outer lips); spire elevated; whorls rounded; aperture ovate-lunate; outer lip with thickened margin; inner lip calloused. **Cret.** (southwestern U. S. A.; Mex.).

T. elevatum Shumard (**198**—34). Shell ovate, spire produced; whorls six, regularly convex; body whorl shorter than spire. **Cret.:** Kan. (Kiowa, Champion), Tex.

LUNATIA Gray 1847

(**Natica ampullaria* Lamarck). Shell ovate-subglobose, rather thin; spire elevated; aperture ovate to semilunar; inner lip thin, or sometimes a little thickened above; umbilicus moderate, or without callosity; operculum corneous. **Cret.–Recent.**

L. pedernalis (Roemer) (**198**—33). Very large, whorls embracing to a little above middle, last one

PLATE 198

[Figures are x1 unless otherwise indicated.]

1–4. Sinum spp. **1, 2. S. fragile** [Md G S, Mioc]. **3. S. scopulosum** [USGS, PP 59]. **4. S. bilix** [B Am Pal 3 (11)]. **5, 6. Neverita** spp. **5. N reclusiana** [San Diego Soc N H, M 1]. **6. N. duplicata** [Tryon, Man Conch 2]. **7–9. Vanikoropsis** spp. **7, 8. V. tuomeyana** [USGS Ter 9] Portion of surface enlarged; apertural view of an incomplete shell, the type. **9. V. suciensis** [USGS, B 51]. **10–22. Gyrodes** spp. **10–12. G. supraplicata** [USGS, PP 137]. Apertural, basal, and top views. **13–15. G. petrosa** [Pal N J 2]. Apertural, back, and top views. **16, 17. G. abyssina** [Pal N J 2]. Basal and apertural views of an internal filling. **18, 19. G. conradi** [USGS, B 106]. Apertural view of type (after Meek) and back view of another specimen. **20. G. depressa** [USGS, B 106]. **21, 22. G. expansa** [Pal Cal 1]. Top and apertural views. **23–25. Polinices** spp. **23, 24. P. (Euspira) halli** [USGS, PP 137]. Apertural and back views. **25. P. shumardianus** [Pal Cal 1]. **26–33. Lunatia** spp. **26, 27. L. subcrassa** [USGS, PP 128]. Apertural and back views. **28. L. lewisii** [San Diego Soc N H, M 1]. **29–32. L. halli** [Pal N J 4]. Four internal fillings showing variation in form. **33. L. pedernalis** [Biol Soc Wash, Pr 8]. Distorted internal filling (x0.4). **34. Tylostoma elevatum** (x2) [Kan G S, B 9].

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ventricose, somewhat separated. **L. Cret.:** Tex. (Glen Rose, Comanche Peak).

L. halli (Gabb) (**198**—29–32). **U. Cret.** (Ripley). N. J., Ala., Miss.

L. subcrassa (Meek and Hayden) (**198**—26, 27). **U. Cret.** (Montanan): Sask., Alta; N. and S. Dak., Mont., Colo.; also Lance of N. Dak.

L. lewisii (Gould) (**198**—28). **Mioc.?, Plioc., Pleist.:** Cal.; **Recent:** Duncan Bay, B. C., to Santa Barbara, Cal.

NATICA Scopoli 1777

(**Nerita vitellus* Linnaeus). "Form genus," so long used for a "catch-all" that it no longer has precise biological significance, and the same may be said for fossil "Naticas"; as used here, the genus includes shells ranging in form from globose to pyramidal, with smooth and lustrous (rarely striated) surface; typically with umbilicus which is often more or less covered by a callus; some groups nonumbilicate; aperture semicircular to oval with thickened inner and sharper outer lip; operculum calcareous. **Trias.–Recent** (N. America).

"N." (Tectonatica) clausa Broderip and Sowerby (**199**—1). **Mioc.:** Wash. (Montesano), Ore. (Empire); **Plioc.:** Ore. (Coos), Cal.; **Pleist.:** Alaska; Cal.; Japan; England; **Recent:** Arctic and Bering seas, south to San Diego, Cal., on the east and to Japan on the west; Arctic off northern Europe and Greenland; south in Atlantic to Mass. and off Portugal in deep water.

"N." williamsi Cragin (**199**—5, 6). Nonumbilicate, of five whorls; spire short, of much embraced somewhat sunken whorls and large body whorl; aperture long, narrowing upward. **U. Jura.:** Tex. (Malone), Utah (Twin Creek).

N. marylandica Conrad (**199**—2). Suborbicular to subovate, with low, broad spire of five volutions; whorls slightly depressed below suture; aperture with faint posterior canaliculation; umbilicus moderate. **Eoc.:** Nanjemoy, Aquia of Md., Va. (A closely related species, **N. eminula** Conrad, occurs in the **Claiborne** of Ala. and Tex.)

N. semilunata Lea (**199**—4). Callus of inner lip partly covering umbilicus, which normally is surrounded by a carination. **Eoc.:** Ala. (Claiborne).

N. mediavia Harris (**199**—3). With about five whorls, slightly shouldered or flattened near depressed sutures; large globular body whorl; aperture elliptical, with thickened lip forming a varix. **Paleoc.** (Midway): Ga., Ala.

XENOPHORA Fischer 1807

(**X. laevigata* Fischer = *Trochus conchyliophorus* Born). Broadly conical or trochiform, whorls flat, abruptly angulated; angulation often prolonged as a sharp, sometimes spinous rim or carina; basal portion flat or rounded, surface commonly with agglutinated foreign particles. **Cret.–Recent** (Atlantic and Gulf coastal region).

X. leprosa (Morton) (**199**—10, 11). Carina apparently absent, the internal fillings appearing rounded at angle; embracing of whorls not quite to angle; surface generally showing cicatrices where foreign particles were attached. **U. Cret.:** Monmouth of N. J., Del; Ripley of Tenn.; Selma of Ala., Miss.; Navarro of Tex.

***X. conchyliophora** (Born) (**199**—7–9). With moderately overhanging carina, emarginate on outer (lower) side; umbilicus covered by callus; generally covered with shell fragments. **Mioc.–Recent:** Atlantic Coast and Gulf States; **Recent** from Cape Hatteras to Gulf of Mexico and West Indies.

VIVIPARUS Martini 1767

(= VIVIPARUS Montfort 1810;
PALUDINA Férussac 1812)

(**V. fluviorum* Montfort = *Helix viviparus* Linnaeus). Conical or turbinate shells with acute spire of rounded or flattened whorls; suture depressed, and often accentuated by thickening of shell below aperture, with continuous peristome; umbilicus minute or absent; habitat fresh-water. **?Penn.** (Carb.), **?Trias., Cret.–Recent** (worldwide distribution).

V. (Viviparus) couesii White (**199**—17). Body whorl somewhat flattened and slightly shouldered without angulation. **U. Cret.:** Wyo. (Bear River).

V. (Viviparus) conradi Meek and Hayden (**199**—15, 16). Apical angle from 45° to 60°; sutures scarcely impressed, whorls nearly flat, angulated below. **U. Cret.:** Sask. (Belly River), Alta.; Mont. (Pierre).

V. (Paludotrochus) trochiformis (Meek and Hayden) (**199**—12, 13). With three revolving spirals or angulations, between which shell is flattened. **Eoc.:** N. Dak., Mont., Wyo., Colo., Utah, N. Mex.;

PLATE 199

[Figures are x1 and from USGS, An Rp 3 unless otherwise indicated.]

1–8. Natica spp. 1. N. (Tectonatica) clausa [San Diego Soc N H, M 1]. **2. N. marylandica** [Md G S, Eoc]. **3. N. mediavia** [B Am Pal 1 (4)]. **4. N. semilunata** [B Am Pal 3 (11)]. **5, 6. N. williamsi** [USGS, B 266]. Apertural and back views. **7–11. Xenophora spp. 7–9. X. conchyliophora** [Md G S, Mioc]. Apertural, top, and basal views (x0.7). **10, 11. X. leprosa** [USGS, PP 137]. Basal and top views. **12–17. Viviparus spp. 12, 13. V. (Paludotrochus) trochiformis. 14. V. (Viviparus) raynoldsianus. 15, 16. V. (Viviparus) conradi.** Views of two specimens. **17. V. (Viviparus) couseli. 18, 19. Scalez petrolia** [Cal Ac Sc, Pr 13]. External (concave) and internal (convex) sides of fossil operculum (x6). **20–22. Campeloma spp. 20, 21. C. vetulum.** Apertural and back views of type. **22. C. multistriatum.** Copy of Meek's original figure. **23–26. Tulotoma thompsoni.** Specimens showing increasing nodosity. **27–31. Valvata spp. 27, 28. V. (Valvata) subumbilicata** [USGS Ter 9]. Top and basal views of type (x3). **29–31. V. scabrida** [USGS, B 29]. Three views of a shell. **32–38. Calyptraea spp. 32–34. C. centralis** [Md G S, Mioc]. Side, dorsal, and ventral views. **35, 36. C. mamillaris** [San Diego Soc N H, M 1]. Side and ventral views. **37. C. diegoana** [Ac N Sc Phila, Pr 78]. **38. C. aperta** (x0.6) [Md G S, Mioc]. **39. Crucibulum spinosum** [Pacific RR Rp 5]. **40–44. Crepidula spp. 40, 41. C. plana** [Md G S, Mioc]. **42, 43. C. fornicata** [Md G S, Mioc]. **44. C. lirata** [Conrad: Fos Shells Tert Fm 1 (3)].

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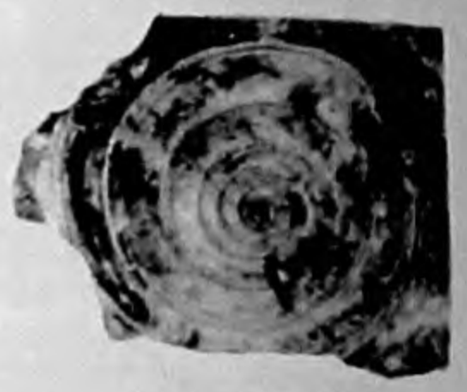

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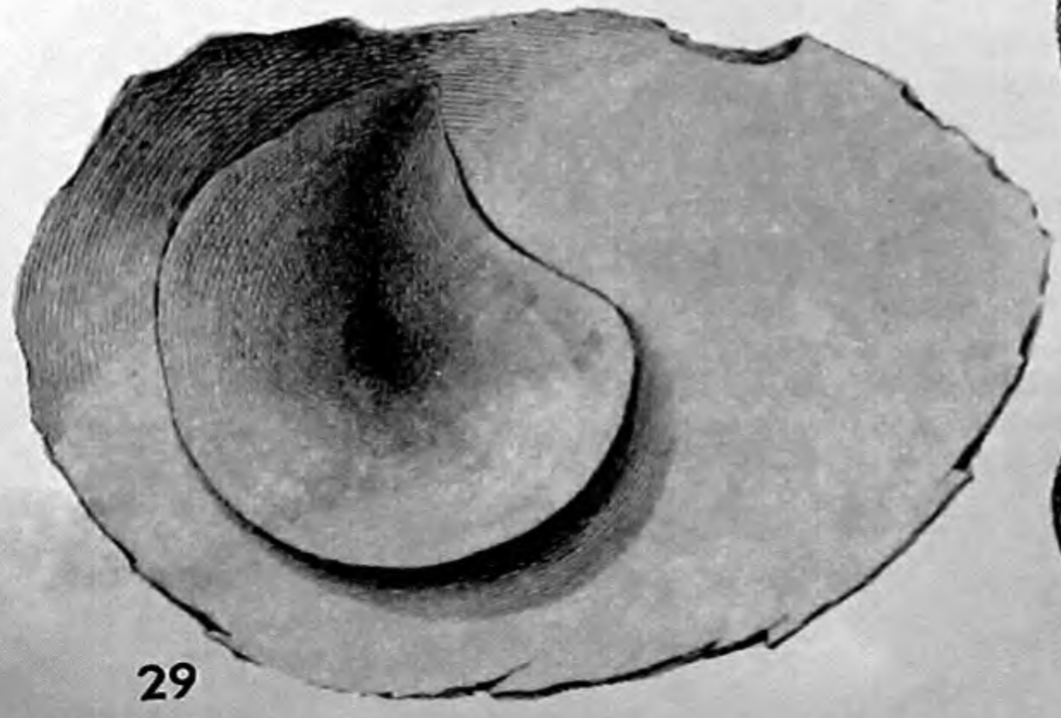

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B. C. (some of these references may be **U. Cret.** according to Henderson (1935, 175)).

V. (Viviparus) raynoldsianus Meek and Hayden (**199**—14). Smooth, round whorled, with apical angle of 60° to 65°; aperture nearly circular; umbilicus small. **Eoc.:** Mont. (Fort Union), Colo., Utah.

SCALEZ Hanna and Gaylord 1924

(**S. petrolia*). Shell calcareous, thin, flattened, ovate; nonspiral, concentric nucleus (apex) placed a short distance beneath dorsal margin, but almost in center, longitudinally; exterior with concentric growth lamellae; interior smooth, and with a depressed groove near ventral margin; considered an operculum of a fresh-water gastropod. **L. Cret.–Paleoc.** (western U. S. A.).

***S. petrolia** H and G (**199**—18, 19). **Plioc.:** Cal. (subsurface).

CAMPELOMA Rafinesque 1819

(**C. crassula*). Like *Viviparus* (*sl*), but thick-shelled and with thickened inner lip; smooth, rarely with exceedingly fine spirals; habitat fresh-water. **U. Cret.–Recent** (N. America; ?Europe).

C. vetulum (Meek and Hayden) (**199**—20, 21). Small, inner lip scarcely thickened; umbilical region indented; surface obscurely spiraled. **U. Cret.:** Judith River and Belly River of Mont.; Sask. and Alta; Lance of Mont., Wyo.

C. multistriatum Meek and Hayden (**199**—22). Apical angle about 45°; sutures impressed; no shelf; whorls round. **U. Cret.** (Laramie): Wyo., Colo.; Alta.; **Eoc.:** N. Dak. (Fort Union).

TULOTOMA Haldeman 1840

(**Paludina magnifica* Conrad). Like *Viviparus* but with angular whorls; fresh-water. **Cret.** (N. America).

T. thompsoni White (**199**—23–26). **U. Cret.:** Lance of Mont., Wyo., Colo.; Mesaverde–Fruitland of Colo., N. Mex.

VALVATA Mueller 1774

(**V. cristata*). Small umbilicate shells of naticoid form, with a few regularly enlarging whorls forming a conical or discoidal spire; aperture circular, peristome continuous; operculum horny, multispiral; habitat fresh-water; numerous subgenera and species. **Jura.–Recent** (worldwide distribution).

V. scabrida Meek and Hayden (**199**—29–31). Minute, rather loosely coiled, with obtuse conical spire and deeply impressed sutures; aperture circular. **U. Jura.** (Morrison and equivalents) **L. Cret.:** Wyo., Colo.

V. (Valvata) subumbilicata (Meek and Hayden) (**199**—27, 28). Large, few whorled, spire low, umbilicus small. **Eoc.** (Fort Union): N. Dak., Mont.

CALYPTRAEA Lamarck 1799

(**Patella chinensis* Linnaeus). Thin, conical, spiral shells, with last whorl greatly expanded; aperture basal, with an internal spiral diaphragm which has a twisted columellar border. **U. Cret.–Recent.**

C. diegoana (Conrad) (**199**—37). **Eoc., Olig.:** Wash. to Cal.

C. aperta Solander (**199**—38). Large, gibbous, with regularly enlarging spirals, the later ones strongly spinous. **Eoc.:** Gulf Coast; **Mioc.:** Md. (Choptank, Calvert), N. J. (Shiloh); **M.** and **U. Eoc.** of Hampshire and Paris basins.

C. centralis Conrad (**199**—32–34). Conical, with apertural rim projecting beyond last whorl; surface smooth except for a few irregular spiral lines and growth lines. **Mioc.:** Md. and Va. (St. Marys), N. C. (Yorktown), N. and S. C. (Duplin), Fla. (Choctawhatchee); Costa Rica; Dominican Republic; Trinidad; **Plioc.:** N. C. (Waccamaw), Fla. (Caloosahatchee); Trinidad; **Recent:** Cape Hatteras to Gulf of Mexico and West Indies in 1 to 52 fathoms.

C. mamillaris Broderip (**199**—35, 36). **Mioc.:** Ore. (Empire), Cal. (San Pablo); **Plioc., Pleist.:** Cal.; **Recent:** Alaska to S. America.

CRUCIBULUM Schumacher 1817

(**Patella auriculata* Chemnitz and Dillwyn = *Patella auricula* Gmelin = *Crucibulum planum* Schumacher). Patelloid shells with coiled protoconch and strongly expanding body whorl; platform deeply concave, producing cup and saucer aspect. **Tert.–Recent** (Atlantic and Pacific Coasts).

C. grande Say (**200**—29, 30). **Mioc.:** Va., N. C.

C. costatum (Say) (**200**—31, 32). With strong plications often extending to beak; cup free at periphery in adult. **Mioc.:** Va. (St. Marys, Yorktown), S. C. (Duplin), Fla. (Choctawhatchee).

***C. auriculum** (Gmelin). Depressed, with fine, radiating, frequently dichotomous lines on upper surface. **Mioc.–Recent:** S. C. (Waccamaw), Fla. (Choctawhatchee, Caloosahatchee); **Recent:** Fla. and Gulf of Mexico to northern Brazil at 25 to 100 fathoms.

PLATE 200

[Figures are x1 unless otherwise indicated.]

1–3. Melania spp. [USGS, An Rp 3]. **1. M. insculpta. 2, 3. M. wyomingensis.** Views of two shells. **4. Goniobasis chrysalis** [USGS, An Rp 3]. **5–7. Pyrgulifera humerosa** [USGS, An Rp 3]. Back view of small shell; apertural and back views of a large shell. **8–12. Littorina** spp. **8–10. L. scutulata** [San Diego Soc N H, M 1]. Apertural views of three shells (x2). **11, 12. L. berryi** [USGS, PP 137]. Type (x2). **13–25. Architectonica** spp. **13, 14. A. (Stellaxis) alveata** [Conrad: Fos Shells Tert Fm 1 (3)]. Apertural and basal views. **15. A. (Stellaxis) cognata** (x1.5) [Ac N Sc Phila, Pr 78]. **16–25** [Carnegie Inst, Pub 385]. **16–18. A. (Pseudotorinia) eupreps.** Views of holotype (x4). **19–22. A. (Psilaxis) krebsii lampra** (x4). Three views of holotype and top view of a smaller shell showing sculpture of early whorls. **23–25. A. (Architectonica) nobilis quadriseriata.** Three views of a shell (x1.5). **26, 27. Caecum mexicanum** (x18) [JP 11]. Young shell; adult shell, the holotype. **28. Caecum (Micranellium?) patuxentium** [Md G S, Mioc]. **29–32. Crucibulum** spp. **29, 30. C. grande** [Ac N Sc Phila, J (2) 4]. Ventral and side views. **31, 32. C. costatum.** [Md G S, Mioc]. Dorsal and ventral views (x0.7).

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C. spinosum (Sowerby) (**199**—39). **Plioc.:** Cal.; **Pleist.:** Cal.; L. Cal. and Oaxaca, Mex.; **Recent:** Trinidad; Cal.; L. Cal. to Tome, Chile, and the Galapagos Islands.

CREPIDULA Lamarck 1799

(**Patella fornicata* Linnaeus). Slipper-shaped, with beak nearly or quite marginal, and often enrolled; elongate aperture is partly covered by a platform or thin lamellar expansion of inner lip. **U. Cret.–Recent** (Atlantic Coast).

C. lirata Conrad (**199**—44). Beak much produced, strongly curved to side and forward, with subspiral apex; form narrow, elongate and deep; surface with irregular striae or costae and transverse wrinkles. **Eoc.:** Ala. (Claiborne).

C. plana Say (**199** –40, 41). Flat; apex marginal, not enrolled; shell elongate; platform covering about half shell length. **Mioc.** and **Plioc.:** Atlantic Coast; **Pleist.:** Atlantic and Gulf Coasts; **Recent:** Prince Edward Island to Tex.

***C. fornicata** (Linnaeus) (**199**—42, 43). Convex, with enrolled apex and deeply set platform. Widely distributed in marine **Mioc.–Recent** of the Atlantic and Gulf Coasts of N. Amercia. **C. onyx** Sowerby of the **Mioc.–Recent** of the Pacific Coast of N. America may be a variety of, or identical with, *C. fornicata*.

C. princeps Conrad (**201**—20, 21). Shell large, about one and a half whorls; apex curved sharply in and up. **Mioc.:** Alaska; Wash., Ore., Cal.; **Plioc., Pleist.:** Cal.

GONIOBASIS Lea 1862

(**G. osculata*). Turreted shells with surface ranging from smooth to spirally striate, ribbed, or with sharp nodes upon angulation of whorls; aperture oval, rounded anteriorly; operculum horny, apex usually bursting open. **Cret.–Recent.** (N. America).

G. chrysalis Meek (**200**—4). **U. Cret.:** Wyo. (Bear River).

MELANIA Lamarck 1799

(**M. amarula* Linnaeus). Shell smooth or spirally striated, or with transverse ribs or nodes; aperture oval, rounded anteriorly; differs from *Goniobasis* in being viviparous rather than oviparous. **Jura.–Recent.**

It is possible that the following species should not be assigned to this genus.

"M." wyomingensis (Meek) (**200**—2, 3). Young like adult *Goniobasis*; later whorls abruptly angulated, with concave shoulders and ribs replaced by spinose nodes on angulation; spirals simple, not strong. **U. Cret.:** Laramie of Wyo., Colo.; Edmonton of Sask., Alta.

"M." insculpta (Meek) (**200**—1). Sutures scarcely impressed, ribs continuous on flattened whorls, thick, round, and separated by impressed lines only. **U. Cret.** (Laramie): Colo., Wyo.; **Montanan:** Dakotas (Fox Hills), Colo. (Fruitland), Wyo. (Mesaverde), N. Mex. (Fruitland).

PYRGULIFERA Meek 1871

(**Melania humerosa*). Thick, elongate, oval shells; whorls with narrow shoulder bounded by strong angulation on which ribs are produced as spinose tubercles; spirals numerous but subdued; aperture oval, sometimes with very faint canal. **Cret.–Eoc.** (N. America; Europe; Asia; India).

***P. humerosa** (Meek) (**200**—5–7). Shoulder concave, tubercles strong, blunt, and produced downward as ribs which die away on lower body whorl; spirals broad but generally faint; a faint indication of anterior notch in aperture. **U. Cret.** (Bear River): Wyo., Idaho, Utah.

LITTORINA Férussac 1822

(**L. littoralis*). Shell thick, turbinate, columellate; aperture rounded; outer lip sharp; inner lip smooth, excavate; sculpture of weak spiral lines. **Cret., Eoc.–Recent** (Atlantic Coast of Europe and N. America; Pacific Coast of N. America).

L. berryi Wade (**200**—11, 12). Characterized by its spiral ridges and growth lines, and by its thin outer lip, which is slightly crenulate. **U. Cret.:** Tenn. (Ripley).

L. scutulata Gould (**200** –8–10). **Pleist.:** Cal. to Mex.; **Recent:** Kodiak Island, Alaska, to L. Cal., Mex.

ARCHITECTONICA "Bolten" Roeding 1798

(= SOLARIUM Lamarck 1799)

(**Trochus perspectivus* Linnaeus). Depressed-conical to flat and deeply umbilicated shells, with strong peripheral angulation in the most specialized species; nuclear whorls heterostrophic; surface smooth or with spirals; aperture quadrilateral; umbilicus with notched margins or spiral; operculum horny. **Cret.?, Eoc.–Recent** (Atlantic and Pacific Coasts of N. America).

A. (Stellaxis) alveata (Conrad) (**200**—13, 14). Spire trochiform; sutures not impressed; whorls flat, smooth, and with two spirals near suture; angula-

PLATE 201

[Figures are x1 unless otherwise indicated.]

1–3. Lemintina spp. [Md G S, Mioc]. **1, 2. L. granifera. 3. L. virginica. 4. Vermicularia spirata** (x3) [Carnegie Inst, Pub 385]. **5. Cassiope branneri** [Ark G S, B 1]. **6–19. Turritella** spp. **6. T. (Haustator) whitei** [USGS, B 106]. **7, 8. T. encrinoides** [Pal N J 2]. Type specimen and portion of surface enlarged. **9–12. T. vertebroides** [9–11: Pal N J 2; 12: USGS, PP 137]. Portion of surface enlarged; an incomplete specimen; an internal filling; a nearly complete shell showing surface sculpture. **13. T. trilira** [USGS, PP 137]. **14–16. T. mortoni** [Md G S, Eoc]. An internal filling and apertural views of two shells (x0.7). **17. T. mortoni postmortoni** (x0.7) [Md G S, Eoc]. **18. T. (Peyrotia) humerosa** (x0.7) [Md G S, Eoc]. **19. T. (Peyrotia) tampae** [Wag Free Inst Sc, Tr 3]. **20, 21. Crepidula princeps** [USGS, PP 59]. Internal view; profile view (x1.2).

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tion sharp, base flattened with peripheral grooved lines; umbilicus deep, margined by ring of triangular dentations. **Eoc.** (Claiborne): Ala., Tex.

A. (Stellaxis) cognata Gabb (**200**—15). Umbilical carina heavily serrated. **Eoc.:** Cal. (Tejon).

A. (Architectonica) nobilis quadriseriata (Sowerby) (**200**—23–25). **Mioc.:** Dominican Republic.

A. (Psilaxis) krebsii lampra Woodring (**200**—19–22). **Mioc.:** Dominican Republic.

A. (Pseudotorinia) euprepes Woodring (**200**—16–18). **Mioc.:** Dominican Republic (Cercado, Gurabo).

CAECUM Fleming 1817

(**Dentalium trachea* Montagu). Coiled part of shell discoidal with one to three whorls; tubular part curved, slowly enlarging and smooth, ribbed or annulated; cross section circular; apertural end closed by a curved or conical septum, sometimes with warty or fingerlike apophyses. **Eoc.–Recent** (worldwide distribution).

C. (Micranellium?) patuxentium Martin (**200**—28). Only sculpture consists of 30 to 40 strong, regular, closely set annulations. **Mioc.:** Md. (Choptank).

C. mexicanum Collins (**200**—26, 27). **M. Mioc.:** Isthmus of Tehuantepec, Mex.

LEMINTINA Risso 1826

(**L. cuvieri* Risso = *Serpula arenaria* Linnaeus). Shell attached or free, tubular, often large, irregularly convoluted; divided at intervals by partitions concave forward; aperture circular; sculpture consisting of fine granular spiral threads. **U. Cret.?; Eoc.** (N. America; Europe; Java)–**Recent** (worldwide distribution).

L. granifera (Say) (**201**—1, 2). **Mioc.?:** Tampa of Fla.; Chesapeake of N. J., Md., Va., N. C.

L.? virginica (Conrad) (**201**—3). Differs from preceding in being less intricately coiled and in lacking surface sculpture except growth lines and wrinkles. **Mioc.:** Va. (St. Marys).

VERMICULARIA Lamarck 1799

(**Serpula lumbricalis* Linnaeus). Shell unattached; first whorls turritelloid, later ones irregularly coiled; surface bearing spiral ridges and also growth lines; aperture round generally. **U. Cret.–Recent** (worldwide distribution).

V. spirata (Philippi) (**201**—4). Shell small; first five to seven whorls forming a slender, turritelloid spire, remaining two or three irregularly coiled or twisted. **Mioc.:** N. C. (Duplin), Fla. (Choctawhatchee); Jamaica (Bowden); Dominican Republic (Cercado, Gurabo); **Plioc.:** N. C., Fla.; Costa Rica; Trinidad; **Pleist.:** N. C.; **Recent:** Eastern coast of U. S. A. from New England south to Bahia and east to Bermuda in 3 to 175 fathoms.

CASSIOPE Coquand 1865

(= GLAUCONIA Giebel 1852; OMPHALIA Zekeli 1852)

(Genotype not discovered; apparently uncertain.) Thick-shelled, conical or turreted, narrowly umbilicate; whorls spirally ribbed, rarely smooth; aperture oval with faint canal; anterior and median slit on outer lip. **Cret.**

C. branneri (Hill) (**201**—5). **L. Cret.** (Trinity): Ark., Tex.

TURRITELLA Lamarck 1799

(**Turbo terebra* Linnaeus). "Form genus," with numerous subgenera and many species, including shells which have high, turreted and pointed spire; numerous variously spiraled whorls separated by moderately incised sutures; aperture oval, round or quadrangular, with thin outer lip and no plications. **Trias.–Recent.**

HAUSTATOR Montfort 1810. Many rather high whorls, flattened on side and separated by deep linear sutures; spiral striae and weak growth lines; aperture rounded quadrangular.

PEYROTIA Cossmann 1912. Larger and more coarsely ornamented than *Haustator*, and with rather deeply incised suture; strong angular ridge at base of whorl just above suture.

TURRITELLA *ss.* Characterized by high, slender turreted shell of many rounded, spirally ridged whorls which are separated by strong sutures; aperture round.

T. (Haustator) whitei Stanton (**201**—6). About 30 slender whorls, when full grown, embracing nearly or quite to moderate angulation; shoulder flat or gently convex; primary spirals six to eight, minutely nodose in later whorls and subspinous in adult; secondary spirals generally present. **U. Cret.** (Coloradoan): Kan., Colo., Utah.

T. vertebroides Morton (**201**—9–12) Slender, long, apical angle about 12°; volutions gently convex with five to six strong primary spirals, with weaker secondary ones, and still fainter tertiaries; suture depressed. **U. Cret.:** Monmouth of N. J.; Peedee of Carolinas; Ripley of Tenn., Ala., Miss.; Nacatoch of Ark.; Navarro of Tex.

T. encrinoides Morton (**201**—7, 8). Center of whorl flattened, basal angle pronounced, whorls embracing to within a short distance of angle; three to four strong primary spirals with strong secondary ones between; internal fillings more compact than in

PLATE 202

[Figures are x1 and from Wag Free Inst Sc, Tr 3 unless otherwise indicated.]

1–25. Turritella spp. 1. T. atacta. 2, 3. T. indenta [Md G S, Mioc]. **4–6. T. plebeia** (x1.2) [Md G S, Mioc]. Fig. 6 is var. **octonaria. 7. T. aequistriata** (x1.5) [Md G S, Mioc]. **8. T. variabilis** (x1.2) [Md G S, Mioc]. **9. T. cumberlandia** [Md G S, Mioc]. **10. T. subannulata.** Type (x2.3). **11. T. apicalis.** Type (x1.8). **12. T. perattenuata** (x0.9). **13, 14. T. (Haustator) pacheoensis** [USGS, An Rp 17 (1)]. Young and adult shells. **15. T. uvasana** (x2) [USGS, B 398]. **16. T. ocoyana** [USGS, B 398]. **17. T. exaltata** [Md G S, Mioc]. **18. T. inezana** [USGS, B 322]. **19–25. T. cooperi** [San Diego Soc N H, M 1]. A number of specimens illustrating variation in form and sculpture.

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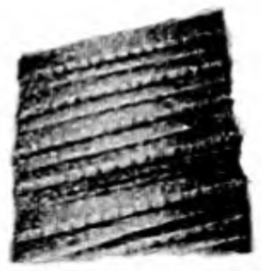

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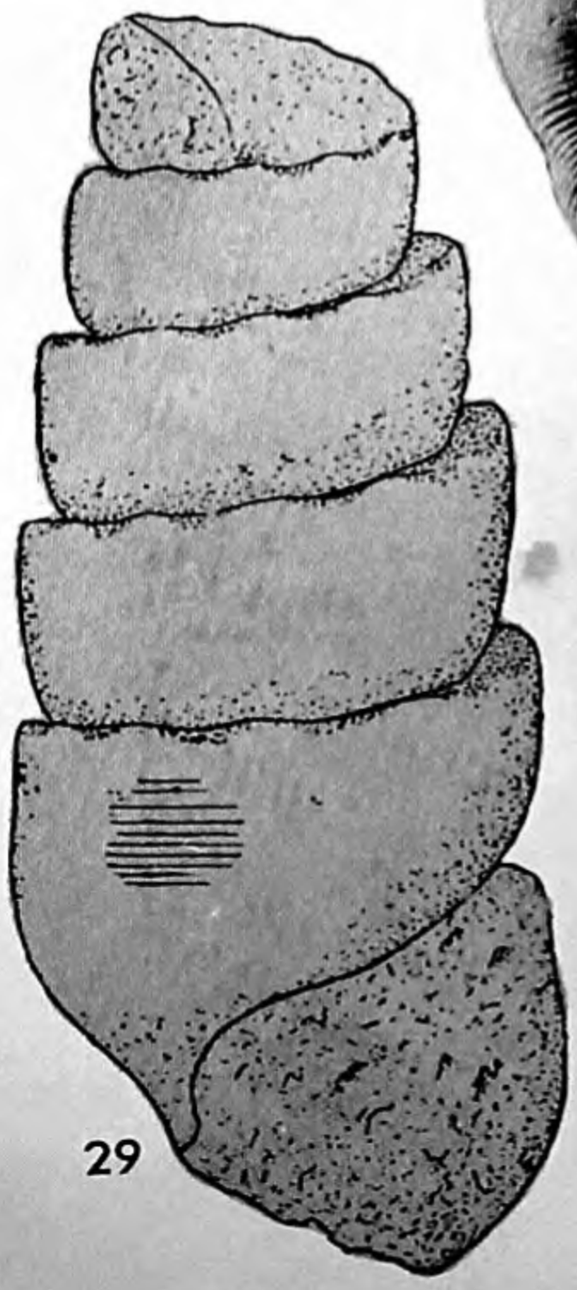

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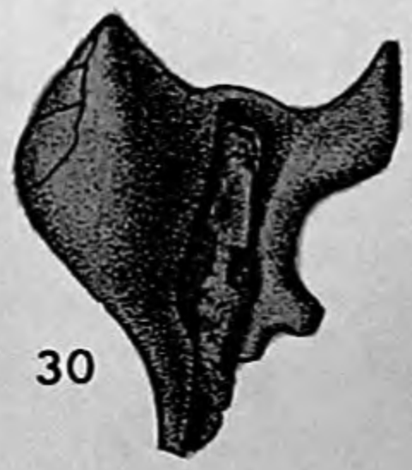

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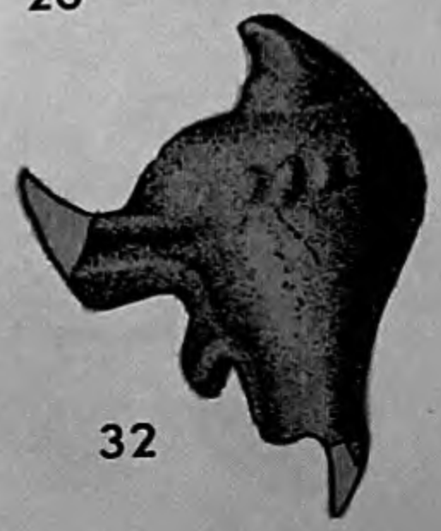

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T. vertebroides. **U. Cret.:** Monmouth of N. J., Md.; Matawan of Del.; Ripley of Tenn.

T. trilira Conrad (**201**—13). Whorls slightly convex, sutures depressed; three strong spirals, a fourth generally covered at suture. **U. Cret.:** N. J. (Wenonah), Md. (Matawan, Monmouth), Carolinas (Black Creek, Peedee), Tenn. (Ripley), Ga. (Eutaw, Ripley), Ala. (Ripley, Selma), Miss. (Eutaw, Ripley), Ark. (Austin, Marlbrook, Nacatoch, Arkadelphia), Tex. (Taylor, Navarro).

T. tippana Conrad. Differs from *T. trilira* in the scarcely depressed suture and in having four spirals, the lower three subequidistant, the upper more distant and stronger; and in having a few intercalated spirals. **U. Cret.:** N. J. (Matawan), Md. (Monmouth), Tenn. and Miss. (Ripley), Tex. (Navarro).

T. mortoni Conrad (**201**—14–16). Volutions angulated, shoulder slightly concave, with two to three primary and several secondary spirals; keel very angulate in specialized varieties (**T. mortoni postmortoni** (**201**—17)); body whorl, below angulation, mostly covered by succeeding whorl; aperture subquadrangular. **Paleoc., Eoc.:** Aquia of Md., Va.; varietal forms in Midway of Tenn., Ala. to Ark. and Tex.; Wilcox of Ala.

T. (Peyrotia) humerosa Conrad (**201**—18). Whorls nearly flat in center, with strong primary and fainter secondary spirals; an angulation near base, visible only in body whorl, and a strong subsutural thickening carinated by two spirals; aperture subquadrate. **Paleoc.:** Aquia of Md.; varietal forms in Ala., Ark., Tex., and Mex.

T. (Peyrotia) tampae Heilprin (**201**—19). Center of whorls slightly concave with a zone of two sunken spirals of three spiral grooves; basal angle pronounced and slightly carinate; sutures scarcely depressed except final gerontic stages; whole surface of shell covered with fine, sharp but almost microscopic spirals. **Mioc.:** Fla. (Tampa).

T. atacta Dall (**202**—**1**). Whorls convex, but convexity marred by three strong spirals. **Mioc.:** Fla. (Tampa).

T. indenta Conrad (**202**—2, 3). With very deep sutures in older whorls owing to abrupt lower and upper angulations, and slight loose coiling; young whorls in contact; sides concave, faintly spiraled. **Mioc.:** Md. (Chesapeake).

T. aequistriata Conrad (**202**—7). Small, whorls embracing nearly up to angulation, above which they are almost flat, except for a second faint angulation or strong spiral some distance below suture, and very fine spirals; aperture longer than wide. **Mioc.:** N. J. (Shiloh), Md. (Calvert).

T. plebeia Say (**202**—4–6). Whorls convex, suture depressed; spirals numerous; var. **octonaria** has whorls flattened (**202**—6), and another has one strong spiral, the others variable. **Mioc.:** (Chesapeake): N. J., Md., Va.

T. variabilis Conrad (**202**—8). Very long and slender, sutures scarcely impressed; four primary spirals, thick, rounded, in pairs, separated by secondary finer ones. **Mioc.:** Same as preceding; also N. C. (Chesapeake).

T. cumberlandia Conrad (**202**—9). With two, rarely three, strong spirals and numerous finer ones; suture closed or depressed. **Mioc.** (Chesapeake): N. J., Md., Va.

T. exaltata Conrad (**202**—17). Slender like preceding, with strongly carinate angle overhanging; shoulder concave with faint spirals, one near suture. **Mioc.:** Md. (Calvert), Va. (St. Marys).

T. subannulata Heilprin (**202**—10). Main angulation at center of whorl pronounced; whorls flat and sloping above, vertical below to second carina, after which whorl rounds downward; whorls embracing nearly to second carina; strong spiral above suture. **Mioc., Plioc.:** Carolinas (Waccamaw), Fla. (Caloosahatchee).

T. perattenuata Heilprin (**202**—12). Very long and slender, whorls deeply concave in middle, a strong, rounded, commonly cancellated spiral above basal angulation, and a stronger double or triple one at a similar distance below suture, which is broadly depressed; one to two faint spirals in concave space of adult whorls. **Plioc.:** Fla. (Caloosahatchee).

T. apicalis Heilprin (**202**—11). Shorter and more rapidly tapering than *T. perattenuata*, with a similar cancellated median spiral; upper carina single. **Plioc.:** Fla. (Caloosahatchee).

T. (Haustator) pacheoensis Stanton (**202**—13, 14). **Paleoc.:** Cal. (Martinez).

T. uvasana Conrad (**202**—15). Whorls with sides straight, oblique above, rounded below; revolving striae more prominent on lower portion of whorl. **U. Eoc.:** Wash. to Cal. (Tejon).

T. inezana Conrad (**202**—18). High-spired with flatsided whorls obtusely or obscurely carinated on each side of suture. **L. Mioc.:** Cal. (Vaqueros).

PLATE 203

[Figures are x1 unless otherwise indicated.]

1, 2. Nerinea goodelli [USGS, B 266] Longitudinal section and portion of a shell. **3–6. Mesalia** spp. **3, 4. M. seratim-granulata** [Pal Cal 1]. Fragmental specimen and same enlarged. **5. M. martinezensis** [Ac N Sc Phila, Pr 78]. **6. M. vetusta** [B Am Pal 7 (32)]. Back view showing twist in columella (x1.6). **7, 8. Nerinea** spp. [Pal Abhand 4 (4)]. **7. N. cultrispira. 8. N. austinensis. 9–12. Nerinella** spp. **9–11. N. stantoni** [USGS, B 266]. A nearly complete specimen; fragment enlarged (x3); longitudinal section of latter. **12. N. subula** [Pal Abhand 4 (4)]. **13–16. Bittium** spp. [13, 15, 16: Wag Free Inst Sc, Tr 3 (2); 14: San Diego Soc N H, M 1]. **13. B. boiplex** (x7). **14. B. eschrichtii. 15. B. permutabile.** Type (x4.5). **16. B. cossmanni** (x4). **17. Alabina cerithidioides** (x13) [Wag Free Inst Sc, Tr 3 (2)]. **18. Alabina curta** [Carnegie Inst, Pub 385]. Holotype (x8). **19–21. Ectinochilus** spp. **19. E. laqueatum** (x1.3) [B Am Pal 7 (32)]. **20, 21. E. macilentum** [USGS, B 51]. **22. Anchura abrupta** [Ac N Sc Phila, J (2) 4]. **23. Anchura rostrata** [Pal N J 2]. **24, 25. Drepanochilus** spp. [USGS, PP 128]. **24. D. americanum.** Dorsal view of immature specimen. **25. D. americanum pusillum.** Type (x2). **26. Anchura falciformis** [Ac N SoPhila, Pr 78]. **27, 28. Pugnellus densatus** [USGS, PP 137]. **29. Cerithium bosquense** [Tex G S, An Rp 4]. A fragmental internal filling. **30–32. Pugnellus fusiformis** [USGS, B 106].

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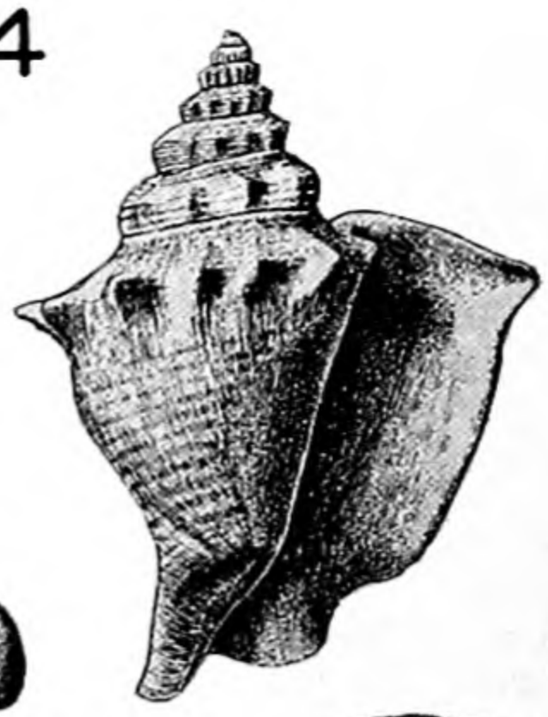

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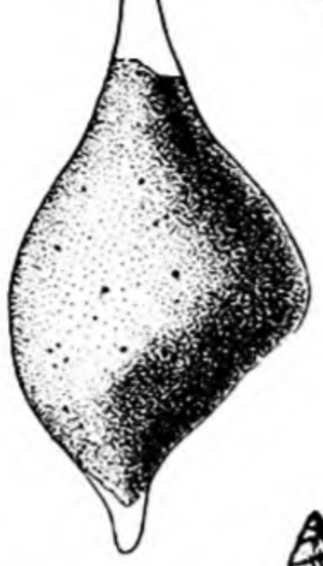

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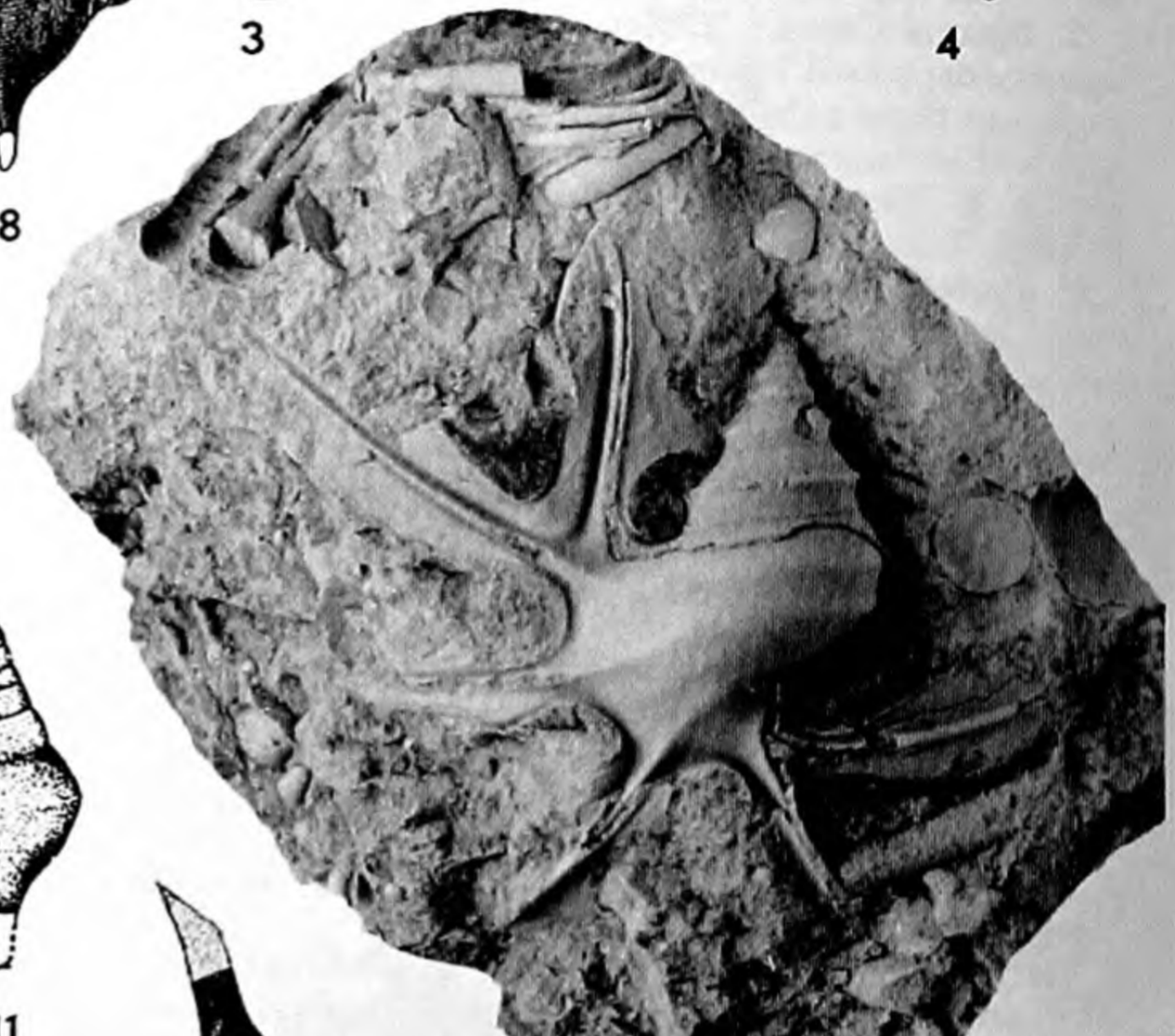

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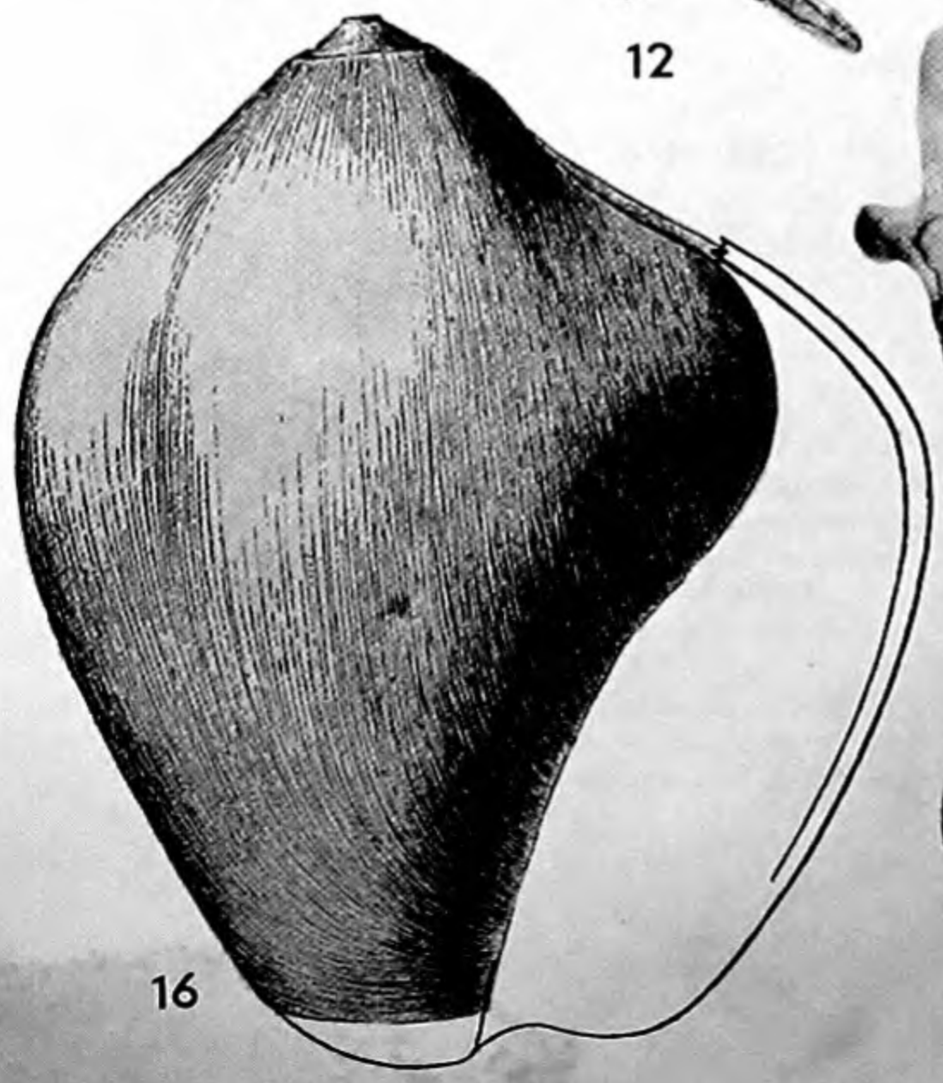

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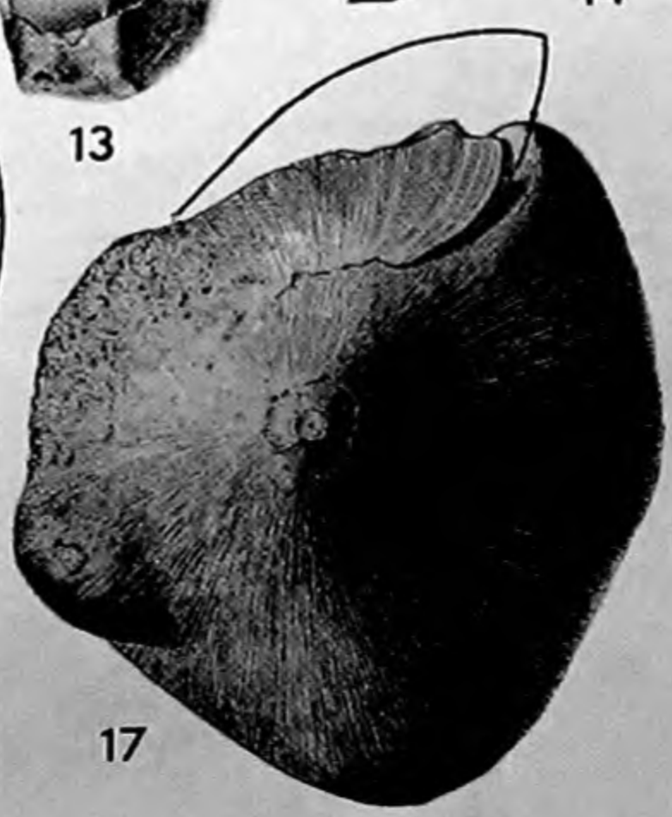

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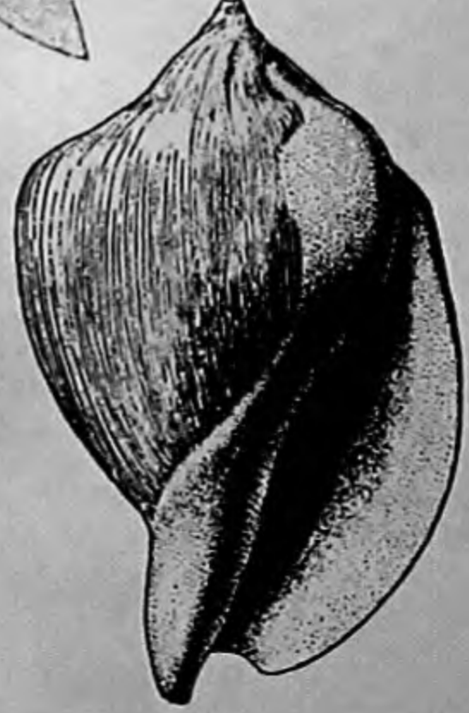

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T. ocoyana Conrad (**202**—16). Whorls with straight sides and rounded base; spiral lines well marked. **Mioc.:** Cal. (U. Vaqueros).

Woodring (1929, 256, 257) has pointed out that large, strongly keeled *ocoyana*-like Turritellas are widely distributed in tropical America. They have been reported from Mex., Columbia and Venezuela on the east; from L. Cal., Panama, Ecuador, and Peru on the west. They come from two middle Mioc. horizons.

T. cooperi Carpenter (**200**—19–25). **Plioc.:** Cal.; **Pleist.:** Cal., L. Cal., Mex.; **Recent:** Cal. Coast.

MESALIA Gray 1840

(**Cerithium mesal* Adanson = *Turritella brevialis* Lamarck). Turritelloid shell with whorls rounded, ornamented with spiral ridges or carinae; aperture oval; differs from *Turritella* in its large apical angle and slightly developed anterior canal. **Cret.** (world-wide distribution)–**Recent.**

M. seratim-granulata (Roemer) (**203**—3, 4). Large, slender, elongate, with numerous whorls flattened on side, each later projecting basally over preceding; alternating spirals noded, varying in number; nodes low and round or elongate, with spirals rather coarse and well separated. **L. Cret.:** Kan. (Dakota), Tex. (Fredericksburg, Washita), N. Mex. (Purgatoire, Washita), Cal.; Mex.

M. martinezensis (Gabb) (**203**—5). Characterized by broadly sinuous outer lip, and but two prominent spiral lines above angle. **Paleoc.:** Cal. (Martinez).

M. vetusta (Conrad) (**203**—6). Sutures sharply impressed, but shallow, spirals fine, alternating in size; ribs arcuate, indistinct, generally obsolete; whorls slightly angulated just below suture; aperture obliquely elliptical, effuse; inner lip somewhat folded, slightly reflected at base. **Eoc.:** Ala. (U. Claiborne).

NERINEA Defrance 1824

(**N. tuberculosa*). Turritelloid in form, but aperture with short anterior notch and columella with simple folds which also are commonly found on both inner and outer lip. **Jura., Cret.** (southwestern U. S. A.; Mex.).

N. goodelli Cragin (**203**—1, 2). Sides of whorls concave, strongly carinated at base, with three or four rather marked spirals; outer wall with one prominent, thin, acute fold internally, extending scarcely half way across the chamber (well seen in longitudinal sections); columella partly hollow and with smaller fold, while a third one occurs near middle of upper side of chamber. **Jura.:** Tex. (Malone). (A related if not identical form occurs in the **U. Jura.** of the Mazipil region of Mex.)

N. austinensis Roemer (**203**—8). Large; apical angle about 20°; whorls gently concave, smooth, basal angulation nodose; columella with two or three sharp folds, middle one if present smallest; outer lip with one sharp fold directed downward. **L. Cret.:** Tex. (Edwards, Glen Rose).

N. cultrispira Roemer (**203**—7). Much more slender than preceding; whorls smooth, strongly concave; basal carina a sharp, bladelike keel; columella with single fold, and outer lip with faint one, obsolete in adult shell. **L. Cret.:** Tex. (Edwards).

NERINELLA Sharpe 1849

(**N. dupini* Orbigny). Like *Nerinea*, but with columellar fold generally wanting; a fold commonly occurs on inside of outer lip. **Jura., L. Cret.**

N. stantoni Cragin (**203**—9–11). Exceedingly slender; whorls with gently concave sides bearing four equidistant spirals; upper and lower angulations sharp and appearing as spirals; no columellar fold but a blunt one on inner side of outer lip. **U. Jura.:** Tex. (Malone), Utah (Twin Creek).

N. subula (Roemer) (**203**—12). Slender and subulate; suture scarcely depressed; sides of whorls flat with two (rarely three) rows of small tubercles on basal portion of body whorl; aperture elongate; no columellar or labial folds. **L. Cret.:** Tex. (Edwards).

BITTIUM Leach 1847

(**Murex reticulatus* Montagu = *Strombiformis reticulatus* Costa). "Form genus" applied to small turreted shells with spirals and costae which generally cancellate each other; aperture with short straight canal and sharp outer lip. **Jura.–Recent** (Atlantic Coast).

B. permutabile Dall (**203**—15). Greatest convexity of whorls below middle of exposed part; costae strong but becoming obsolescent toward suture; spiral fine, often compound; aperture with feeble canal. **Mioc.:** Fla. (Chipola).

B. cossmanni Dall (**203**—16). Shorter and stouter than preceding, with which it occurs.

B. boiplex Dall (**203**—13). Long, slender, round-whorled; three strong spirals cancellating the ribs; occasionally strong varixlike ribs; simple spirals on body of last whorl, and sometimes above suture; aperture without canal. Occurs with preceding.

B. eschrichtii (Middendorff) (**203**—14). **Plioc.:** Ore. (Coos), Cal.; **Pleist.:** Cal.; **Recent:** Sitka Alaska, to Puget Sound.

PLATE 204

[Figures are x1 unless otherwise indicated.]

1–4. Strombus spp. [Wag Free Inst Sc, Tr (1)]. **1, 2. S. aldrichi** (x0.9). **3, 4. S. chipolanus** (x0.8). **5–8. Calyptraphorus** spp. (x0.7) [Md G S, Eoc]. **5, 6. C. jacksoni. 7, 8. C. trinodiferous. 9–11. Aporrhais** spp. [USGS, B 106; after White]. **9. A. (Perissoptera) prolabiata. 10, 11. A. (Lispodesthes) nuptialis.** Type, enlarged; small specimen enlarged (type of *Lispodesthes lingulifera*). **12, 13. Tessarolax distorta** [Ac N Sc Phila, Pr 78]. **14, 15. Pterocerella poinsettiformis** [14. Pal N J 4; 15. U Tex Pub 4101; print furnished by L. W. Stephenson]. Holotype. **16–20. Orthaulax** spp. [Wag Free Inst Sc 3 (1)]. **16, 17. O. pugnax.** Type (x2). **18–20. O. gabbi.** Two views of a mature shell (x0.8); young shell.

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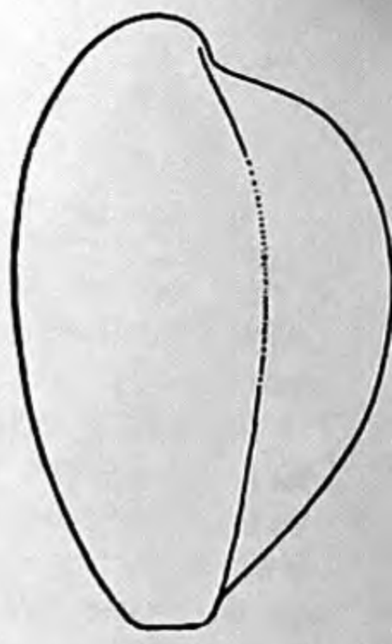

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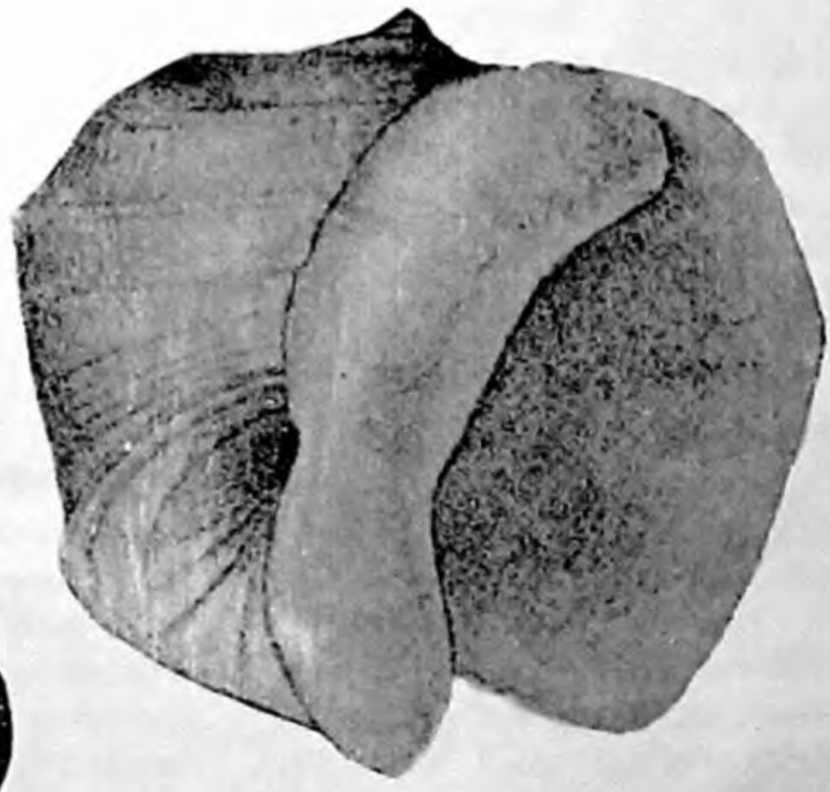

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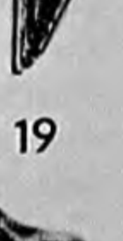

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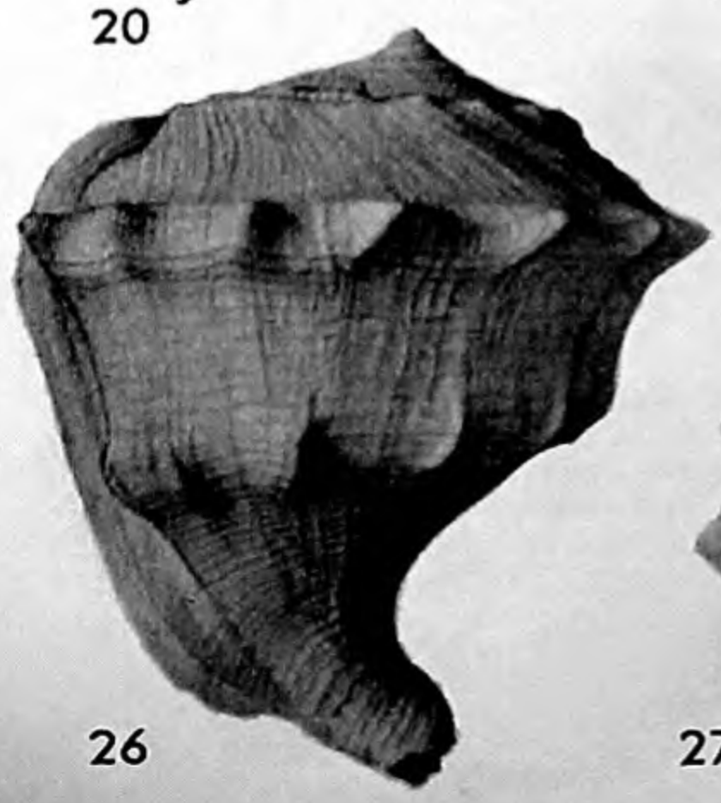

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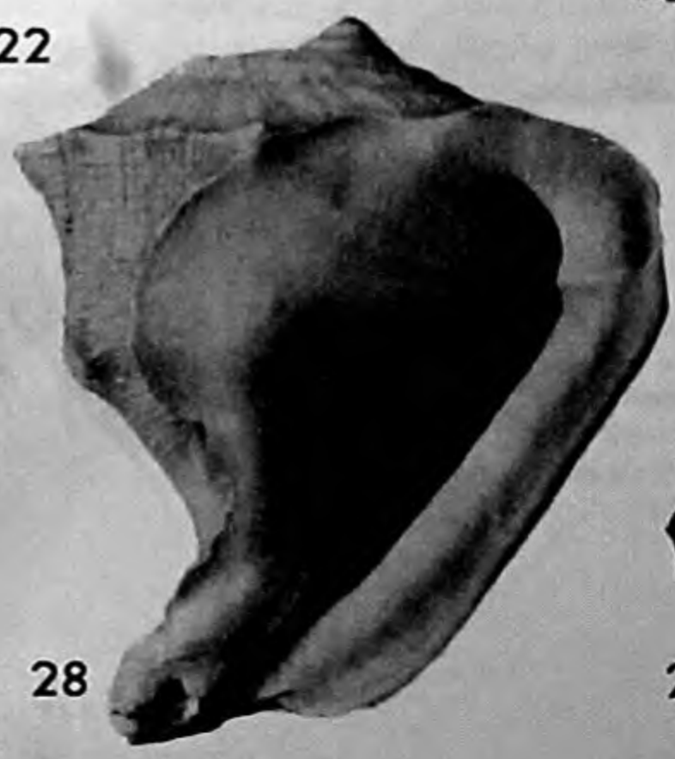

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ALABINA Dall 1902

(**Bittium cerithidioide*). Shell small, slender, body whorl varicose; nucleus slender, consisting of about three smooth whorls; aperture subcircular; basal lip extended and everted; narrow umbilical groove behind inner lip; narrow axial ribs and obscure spiral threads. **Mioc.–Recent.**

***A. cerithidioides** (Dall) (**203**—17). Upper whorls angular, later rounded with only closely set rounded ribs; aperture with very faint anterior notch. **Mioc.–Recent:** Bowden of Jamaica; Caloosahatchee of Fla., Costa Rica; **Pleist.** of S. C.; living off southeastern coast of U. S. A.

A. curta Woodring (**203**—18). **M. Mioc.:** Dominican Republic (Cercado, Gurabo).

CERITHIUM Bruguière 1789

(**C. adansonii* [provisional]). "Form genus," applied to turreted, nonumbilicate, variously sculptured shells; aperture bears a short, backward-curving canal and frequently a notch or short canal on upper or posterior side; columella concave, often with one or two folds; numerous subgenera and species. **Jura.–Recent.**

"C." bosquense Shumard (**203**–29). Large; apical angle 22° to 25°; whorls flattened with 11 to 12 broad, rounded ribs on each; moderately distinct above, but becoming obsolete toward lower suture; aperture ovate, oblique, widest below middle. **L. Cret.** (Fredericksburg): Okla., Tex. (Comanche Peak, Walnut).

ECTINOCHILUS Cossmann 1889

(**Strombus canalis* Linnaeus). Generic features illustrated by species below; the European *Rimella* differs from this genus in having an attenuated rather than a truncated columella. **Eoc.** (Atlantic and Pacific Coasts).

E. laqueatum (Conrad) (**203**—19). High spired; sutures scarcely impressed; ribs acute, slightly curved, restricted to upper part of whorl; spirals fine; outer lip smooth. **Eoc.:** Ala. (Claiborne).

E. macilentum (White) (**203**—20, 21). **Eoc.:** Cal.

ANCHURA Conrad 1860

(**A. abrupta*). Turreted shells with base drawn out into a long canal, with outer lip prolonged into a single winglike expansion which may divide terminally, but is often broken away in specimens; many species referred to *Anchura* almost certainly belong to other genera, some of which are probably new. **Cret.**

***A. abrupta** Conrad (**203**—22). Whorls rounded; ribs like those of *A. rostrata*, but fainter; spiral sculpture faint, becoming angulated on body whorl and lip. **U. Cret.** (Ripley): N. J., Ala., Miss.

A.? rostrata (Gabb) (**203**—23). Apical angle about 35°; early whorls round with slightly impressed suture and obliquely forward-curving, round and close set ribs; body whorl with ribs more distant and becoming obsolete; lip broadly expanded, upper angle somewhat produced. **U. Cret.:** Matawan of N. J., Md.; Ripley of Miss.

A.? sublaevis (Meek and Hayden). Much smaller than *A. abrupta*; high spired with round whorls marked by faint spirals only **U. Cret.** (Pierre): S. Dak., Wyo.

A. falciformis (Gabb) (**203**—26). **U Cret.:** Cal. (Chico).

DREPANOCHILUS Meek 1857

(**Rostellaria americana* Evans and Shumard [preoccupied]; renamed *Arroges* (*Drepanochilus*) *evansi* Cossmann). Like *Anchura*, but outer lip terminates in a single backwardly curved, scythe-shaped, pointed process. **Cret.**

***D. americanum** (E and S) (**203**—24). **U. Cret.** (Montanan): S. Dak.; Sask., Alta. The *var.* **pusillum** Stanton (**203**—25) is abundant in the Lance of the Dakotas.

PUGNELLUS Conrad 1860

(**Strombus densatus*). Young shell fusiform, adult suboval; inner lip massive, extending as a callus over whorls; outer lip variously lobed. **U. Cret.** (worldwide distribution).

***P. densatus** (Conrad) (**203**—27, 28). Outer lip suddenly thickened with a groove behind the raised margin; sculpture of five to six strong costae on final whorl. **U. Cret.** (*Exogyra costata* zone): Atlantic and Gulf regions (N. J. to Tex.).

P. fusiformis Meek (**203**—30–32). Spire somewhat curved; body whorl somewhat nodose; outer lip with falciform extension and several pronounced lobes. **U. Cret.** (Coloradoan): Wyo., Colo., Utah.

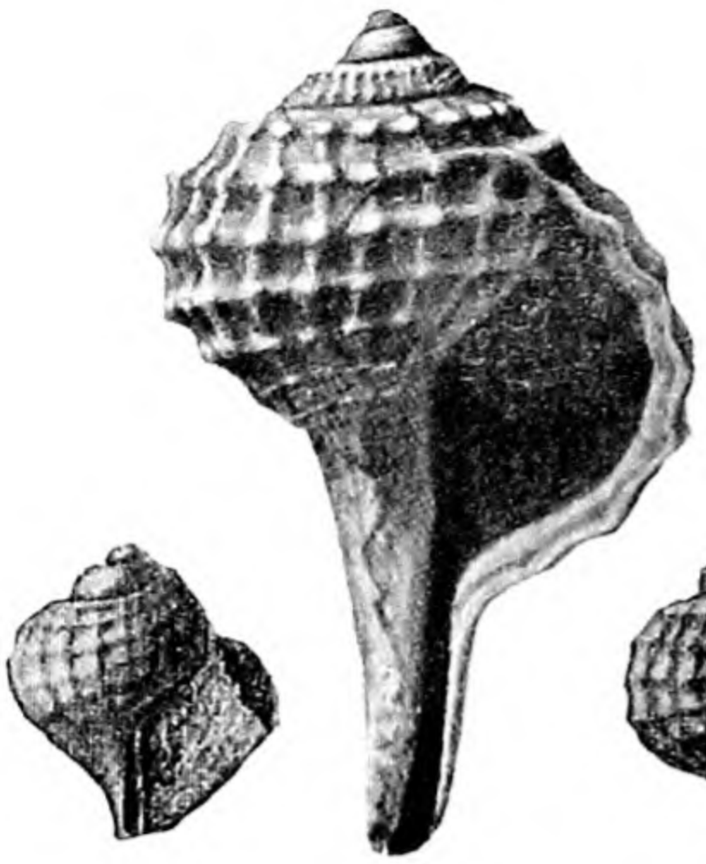
ORTHAULAX Gabb 1872

(**O. inornatus*). Shell rounded-fusiform, canal moderate, straight and regularly tapering; adult shell enveloped over whole spire by extension of

PLATE 205

[Figures are x1 unless otherwise indicated.]

1–3. Calyptraphorus velatus nodovelatus [B Am Pal 7 (32)]. Syntypes (x1.3, x2, and x1.6). **4. Cypraea spadicea** [San Diego Soc N H, M 1]. **5, 6. Cypraea tumulus** (x1.3) [Wag Free Inst Sc, Tr 3 (1)]. **7, 8. Sulcocypraea lintea** [B Am Pal 7 (32); after Aldrich]. **9–11. Trophosycon ocoyanum** [San Diego Soc N H, M 1]. Apertural and back views of a typical variety; an internal filling. **12–14. Priscofícus** spp. **12. P. caudatus** [Ac N Sc Phila, Pr 78]. **13, 14. P. (Fulguroficus) juvenis** [Md G S, Eoc]. **15, 16. Ficopsis remondi** [Pal Cal 1]. Apertural view of shell and portion of surface enlarged. **17. Ficopsis penita** [Conrad: Fos Shells Tert Fm 1 (3)]. **18, 19. Priscofícus (Priscofícus) argutus** [Md G S, Eoc]. Type. **20. Levifusus trabeatus** (x0.8) [B Am Pal 3 (11)]. **21. Strepsidura ficus** (x1.5) [Ac N Sc Phila, Pr 78]. **22. Lacinia alveata** [Conrad: Fos Shells Tert Fm 1 (3)]. **23. Ficus mississippiensis** (x2) [USGS, PP 193]. **24. Mitrella carinata gausapata** (x2) [San Diego Soc N H, M 1]. **25. Mitrella communis** (x3) [Md G S, Mioc]. **26–29. Galeodea** spp. **26–28. G. millsapsi** [USGS, PP 193]. Three views of holotype. **29. G. (Mambrinia) koureos** [B Am Pal 3 (3)].



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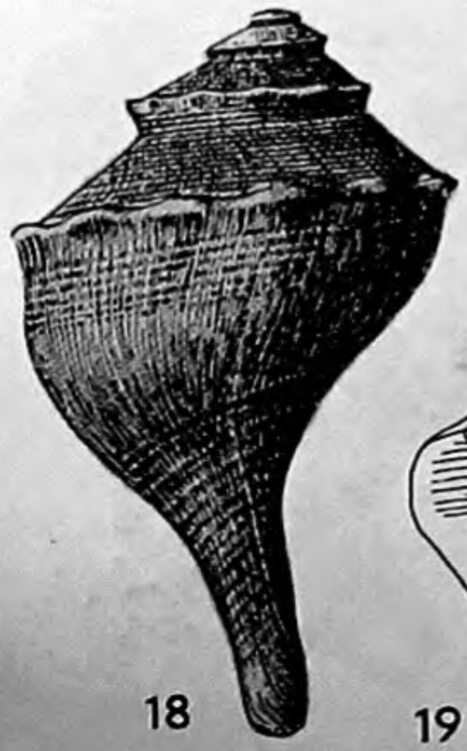

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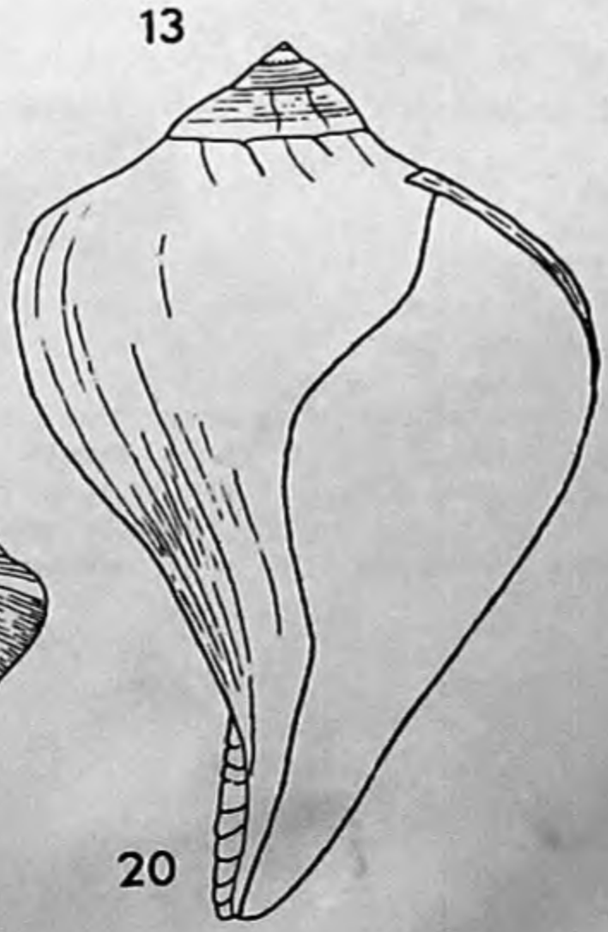

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inner lip; posterior canal fissurelike, formed by continued edge of outer lip and running directly to apex; outer lip apparently sharp and simple; anterior notch oblique and broad; intermediate between *Eostellaria* and *Strombus*; species differentiated by internal fillings and axial sections. **Olig., L. Mioc.** (southeastern U. S. A.; West Indies).

O. pugnax (Heilprin) and var. **hernandoensis** Mansfield (**204**—16, 17). **M.** and **U. Olig.** (Flint River, Suwanee): Antigua; Ga., Ala.; **Mioc.:** Fla. (Tampa).

O. gabbi Dall (**204**—18–20). Very similar to preceding; the two species differ chiefly in shape of posterior end of adult shell, which in *O. gabbi* is nearly always more or less rugose, whereas in *O. pugnax* it is usually smooth. **U. Olig., L. Mioc.:** Fla.; Puerto Rico; Panama Canal Zone.

STROMBUS Linnaeus 1758

(**S. pugilis*). Young shell fusiform with conical spire variously ornamented with ribs, spirals, and tubercles; adult with large body whorl and thick, expanded but not spinose outer lip, often produced posteriorly; sinuate or channeled anteriorly; columellar area smooth, enameled. **Cret.–Recent** (Atlantic and Pacific Coasts; Caribbean).

S. chipolanus Dall (**204**—3, 4). Differs from *S. aldrichi* in its larger size, stronger and sharper shoulder nodules, more slender spire, and less thickened outer lip, with stronger posterior and larger anterior notch, and less elevation posteriorly; body and throat lirate. **Mioc.:** Fla. (Chipola).

S. aldrichi Dall (**204**—1, 2). Youngest whorls round and ribbed, later ones angular, the ribs becoming concentrated as tubercles on the angle, and coarse on body whorl; lip moderately expanded, subrectangular above (posteriorly) with slight posterior and strong, broad anterior (lower) channel. **Mioc.:** Fla. (Chipola).

***S. pugilis** Linnaeus. Larger than *S. chipolanus*; spire low, strongly spinose; body whorl tapering, outer lip not strongly expanded, with deep anterolateral and strong anterior notch; callus of inner lip extensive. **Mioc.:** Haiti, Jamaica, Costa Rica; **Plioc.:** Fla.; Costa Rica; **Pleist., Recent:** Carolinas to Fla. and West Indies. (Forms from West Indian **Mioc.** usually referred to **S. pugiloides** Guppy.)

PTEROCERELLA Meek 1864

(**Harpago tippana* Conrad). Shell small, thin; whorls few, rounded, smooth or subangular; last little enlarged; lip greatly extended and ascending the spire, trilobate; middle lobe much larger and more produced than others, carinated on outer side. **Cret.**

***P. tippana** (Conrad). Spire angulated, with keel and flattened shoulder; lip with six finger-like processes somewhat winged by marginal expansions. **U. Cret.;** Ripley of Tenn., Ga., Miss.

P. poinsettiformis Stephenson (**204**—14, 15). **U. Cret.:** Tex. (Navarro).

TESSAROLAX Gabb 1864

(**T. distorta*). Spire concealed by smooth surface deposits; body whorl with two carnations, each of which bears an irregular blunt node, lower formed after upper and each extending into a canaliculate spine; anterior and posterior ends of aperture drawn out into similar curved canaliculate spines. **Cret.** (western N. America; Europe; India).

***T. distorta** Gabb (**204**—12, 13). **U. Cret.:** B. C. (Nanaimo); Cal. (Chico).

APORRHAIS Costa 1778

(**A. quadrifidus*). Like *Anchura*, but lip with posterior canal either closely adhering to spire or free from same; whorls strongly biangulate; outer lip expanded, lobed or digitate. **Juna.–Recent.**

A. (**Perissoptera**) **prolabiata** White (**204**—9). Spire with rounded whorls marked by rounded ribs more than their width apart; lip with strong, acute spire separated by a rounded sinus from broader subquadrate portion of lip; expansion of lip partly covering next to last whorl. **U. Cret.** (Coloradoan): N. Mex.?, Utah.

A. (**Lispodesthes**) **nuptialis** White (**204**—10, 11). Body whorl with angulation that extends into spinose posterior prolongation of lip; anterior canal straight and rapidly tapering; surface of whorls generally completely enveloped in callous deposits. **U. Cret.** (Coloradoan): N. Mex., Ariz.

CALYPTRAPHORUS Conrad 1857

(**Rostellaria velata*). Differs from *Anchura* in having entire shell more or less covered by expansion of outer lips, which hides character of whorls. **Tert., Recent.**

***C. velatus** (Conrad) (**205**—1–3). Expanded but rounded lip, enamel covering most of whorls, leaving only upper part of spire exposed (and this is covered in adult); rostrum long and pointed; var. *compressus* Aldrich has large gaps in enamel covering upper edge of lip which is much prolonged and pointed. **Eoc.** (Claiborne, Jackson): Gulf States.

PLATE 206

[Figures are x1 unless otherwise indicated.]

1–5. Perissolax spp. **1–3. P. whitfieldi.** 1, 3: Two views of typical form with incomplete anterior canal [Pal N J 2]; 2: Complete shell (x2) [USGS, PP 137]. **4. P. trivolvus** [Pal N J 2]. Type. **5. P. blakei** [Pal Cal 1]. **6. Buccitriton texanum** [USGS, PP 126]. **7. Clavilithes kennedyanus** [B Am Pal 7 (32)]. An immature specimen (x1.7). **8, 9. Pyropsis coloradoensis** (x0.7) [USGS, B 106]. Apertural view of a shell; an internal filling. **10, 11. Pyropsis proxima** [USGS, PP 137]. Two views of type. **12–16. Busycon** spp. **12, 13. B. fusiforme** [Md G S, Mioc]. Views of two shells. **14. B. tritone** (x0.4) [Am Nat 37]. **15, 16. B. (Protobusycon) cretaceum** [AJS (4) 43]. **17. Bruclarkia gravida** [Pal Cal 2]. **18–20. Busycon** spp. **18. B. tuberculatum** [Md G S, Mioc]. **19. B. contrarium** (x0.4) [Am Nat 37]. **20. B. maximum** (x0.4) [Am Nat 37]. **21–23. Sycotypus** spp. **21. S. excavatus** (x0.4) [Am Nat 37]. **22, 23. S. rugosus** (x0.7) [Md G S, Mioc].

C. **triadiferus** Conrad (**204**—7, 8). Ornamentation of early whorls faint; a great prolongation of reflected upper angle of lip. **Eoc.:** Atlantic Coast (Pamunkey), Ala. to Tex. (Wilcox).

C. jacksoni Clark (**204**—5, 6). Large, solid, whorl wholly covered by subsequent expansions. **Eoc.** (Aquia): Atlantic Coast.

SULCOCYPRAEA Conrad 1865

(**S. lintea*). Generic characters illustrated by genotype. **U. Eoc., Olig.**

***S. lintea** Conrad (**205**—7, 8). Sculpture consisting of close set, very fine lines. **Eoc.** (Jackson) and **Olig.** (Vicksburg) of U. S. A.

CYPRAEA Linnaeus 1758

(**C. tigris*). "Form genus"; spires of adult wholly covered by expanded outer lip, which curves inward, leaving a narrow, elongate aperture, both sides of which are strongly lirate; entire surface smooth and polished. **Jura.–Recent.**

C. tumulus Heilprin (**205**—5, 6). Ventricose near middle; outer lip strongly curved at spire, crenulation thick; basal callus rather marked. **L. Mioc.:** Fla. (Tampa).

C. spadicea Swainson (**205**—4). **Plioc., Pleist.:** Cal.; **Recent:** Cal.; L. Cal., Mex.

C. pinguis Conrad. **Eoc.** (Jackson): Miss., La.

TROPHOSYCON Cooper 1894

(**Agasoma? (Trophosycon) kernianum = Sycotypus ocoyanus* Conrad). Young like *Ficus*, adult with two more or less strongly nodose angulations, an upper and lower; canal recurved. **L. Mioc.–L. Plioc.** (Pacific Coast).

***T. ocoyanum** (Conrad) (**205**—9–11). **M. Mioc.:** Wash., Ore., Cal.

FICOPSIS Conrad 1866

(**Hemifusus remondii* Gabb). A high spired, slender *Ficus*; some species angulated. **Eoc.**

***F. remondi** (Gabb) (**205**—15, 16). **Tejon:** Cal.

F. penita (Conrad) (**205**—17). Spire conical; sutures scarcely impressed; body whorl round except for three faint carinae; surface cancellated by spirals and vertical striae; lip thickened toward margin. **Eoc.:** Md. (Nanjemoy), Ala. to Tex. (Claiborne).

PRISCOFICUS Conrad 1866

(**Ficus intermedia* Melleville). Obtusely bicarinate or tricarinate pyriform shells with low, acutely tapering spire; thin, expanded outer lip; long, straight or flexed anterior canal; surface ornamentation of axial and spiral ridges and lines. **Eoc.–Recent.**

P. (Fulguroficus) juvenis (Whitfield) (**205**—13, 14). Shell small, fragile; spire elevated; columella slender, slightly bent; whorls three, marked peripherally by three distinct carinae, the upper nodose, others smooth; entire surface marked by fine revolving lines which alternate, one large and three small below lower carina. **Paleoc., L. Eoc.:** Md. (Aquia); Gulf Province–Midway and Wilcox of Ala. to Tex., and Nuevo Léon, Mex.

P. (Priscoficus) argutus (Clark) (**205**—18, 19) Body whorl with three strong angulations rather far apart, and nodose where they cross the thin, rather sharp and distinct ribs; early whorls more or less rounded. **Eoc.:** Md. and Va. (Pamunkey), Ala. (Wilcox).

P. caudatus (Gabb) (**205**—12). **Paleoc.:** Cal.

FICUS "Bolten" Roeding 1798
(= PYRULA Lamarck 1799)

(**Murex ficus* Linnaeus). Large, thin, inflated, fig-shaped, imperforate shells; spire low, rounded; protoconch smooth, obtuse, few-whorled; sculpture spiral or delicately reticulate; aperture pyriform, terminating anteriorly in a long, open canal; outer lip thin, simple; inner slightly sinuous, nonplicate. **Eoc.–Recent.**

F. mississippiensis Conrad (**205**—23). Surface latticed by large distant spirals and finer ones between, and closely arranged vertical lines. **Olig.:** Miss. (Vicksburg); Nuevo Léon, Tamaulipas.

GALEODEA Link 1807

(**Buccinum echinophora* Linnaeus). Helmet-shaped shells of moderate size and thickness, with six to eight whorls including the small, few-spired naticoid protoconch; surface ornamentation variable. **Eoc.–Recent** (N. America; Europe; Orient).

G. (Mambrinia) koureos Gardner (**205**—29). **Eoc.** (Wilcox): Gulf States; Nuevo Léon, Mex.

G. millsapsi Sullivan and Gardner (**205**—26–28). **Eoc.:** Miss. (Jackson).

MITRELLA Risso 1826

(**M. flaminea = Murex scriptus* Linnaeus). Small, rather high spired and acutely conical; whorls almost flat to moderately ventricose; sutures slightly impressed; spiral sculpture typically on basal part of body whorl; aperture elongate-ovate; outer lip sometimes thickened and denticulate or lirate within; inner lip with or without lirations or denticulations on columella; anterior canal little developed, posterior canal typically undeveloped. **Eoc.–Recent** (Atlantic and Pacific Coasts of N. America).

M. communis (Conrad) (**205**—25). Rather high spire, smooth or with spirals visible only under lens, except on spindle; outer lip strongly denticulate within. **Mioc.** (Chesapeake): N. J., Md.

M. carinata gausapata (Gould) (**205**—24). **Mioc.:** Wash. (Montesano); **Plioc.:** Ore., Cal.; **Pleist.:** Cal.; L. Cal., Mex.; **Recent:** Forrester Island, Alaska, to Salina Cruz, Mex.

LEVIFUSUS Conrad 1865

(**Fusus trabeatus*). General form like a small *Busycon*, but usually with a second angulation on body of whorl; canal of varying length, outer lip lirate; protoconch of several gradually increasing, smooth whorls. **Eoc.** (southern U. S. A.).

***L. trabeatus** (Conrad) (**205**—20). Whorls of spire exposing part of body below angulation; a second angulation in line with posterior end of lip, flat nodules on both angulations, outer lip strongly lirate; canal slightly bent. **Eoc.** (Gosport): Ala.

STREPSIDURA Swainson 1840

(**Fusus ficulneus* Lamarck = *S. turgidus* Solander). A low-spired fusoid with rather long, twisted canal and a liration on inner lip; with short, curved canal, high spire, and whorls often ribbed. **Paleoc.–Olig.**

S. ficus (Gabb) (**205**—21). **Eoc.:** Cal. (Tejon).

PERISSOLAX Gabb 1861

(**Fusus trivolvus*). Spire conical and smooth; canal long; last whorl inflated, biangular, and ornamented with ribs and spirals; columella without plaits; differs from *Pyropsis* chiefly in its long spire; Cretaceous species referred to *Perissolax* should probably be assigned to a new genus. **Cret.?, Eoc.**

"P." whitfieldi (Weller) (**206**—1–3). Small, whorls round; later whorls embracing only to ambitus; flattened below suture; spirals simple, rather coarse, noded by ribs of equal size. **U. Cret.:** N. J. and Md. (Monmouth), Tenn. (Ripley).

***P. trivolvus** (Gabb) (**206**—4). **Eoc.:** N. J. (Vincentown).

P. blakei Conrad (**206**—5). **Eoc.:** Cal.

PYROPSIS Conrad 1860

(**P. perlata*). External sculpture dominantly spiral; body whorl conspicuously inflated, abruptly contracted at base into a slender anterior canal which is often broken away. **U. Cret., Eoc.**

P. coloradoensis Stanton (**206**—8, 9). Canal umbilicated; body whorl not abruptly contracted below, biangulate, the angles with small, rounded nodes, both covered in early whorls; spirals numerous; lip with posterior canal producing a slight channeling of suture. **U. Cret.** (Coloradoan): Kan., Colo., Utah.

P. proxima Wade (**206**—10, 11). **U. Cret.:** Tenn. (Ripley).

BUCCITRITON Conrad 1865

(**Nassa cancellata* Lea = *Buccinum sagenum* Conrad). Like *Tritiaria*, but with shorter anterior canal and more deeply cut siphonal canal. **Eoc.** (Gulf Province).

B. texanum (Gabb) (**206**—6). **Eoc.** (Claiborne): Tex.

LACINIA Conrad 1853

(**Cassidula* (*Lacinia*) *alveata*). Buccinoid shells, with body whorl marked by angulations or spirals, umbilicated aperture with callous columellar lip. **Eoc.**

***L. alveata** Conrad (**205**—22). Large, subglobose, thick body whorl with channeled suture; several angulations with flat or concave interspaces, a strong obtuse carina around umbilicus; aperture large, patulous; inner lip strongly callous, reflected. **Eoc.** (Claiborne): Ala., Tex.

CLAVILITHES Swainson 1840

(= RHOPALITHES Grabau 1904)

(**Fusus noae* (Chemnitz) Lamarck [genotype controversial]). Fusiform shells with cylindrical protoconch of many whorls; early whorls ribbed and spiraled, later ones generally smooth, more elongate and flattened; a posterior canaliculation with sutural shelf generally occurs; columella plicated during early growth stages, but with plications disappearing at maturity. **L. Tertiary** (southeastern U. S. A.; England; France).

C. kennedyanus Harris (**206**—7). **Eoc.** (Claiborne): Tex.

BUSYCON "Bolten" Roeding 1798

(= FULGUR Montfort 1810)

(**Fulgur carica* Montfort = *Murex caricum* Gmelin). Whorls, except very young, angulate with flat shoulder and nodose or spinose angulation, rarely round and smooth; whorls generally embracing to shoulder angle; aperture not abruptly contracted, but canal long; protoconch oblique, smooth. **U. Cret.–Recent** (worldwide).

B. (Protobusycon) cretaceum Wade (**206**—15, 16). Similar to living *B. caricum* (Gmelin), but with an impressed line at base of body. **U. Cret.:** Tenn. (Ripley).

B. fusiforme (Conrad) (**206**—12, 13) Whorls embracing to angle which bears small nodes; shoulder gently concave; aperture moderately contracted. **Mioc.:** Md. (Chesapeake).

B. pyriforme (Conrad). Young whorls tubercled, later keeled; adult with rounded whorls. **Mioc.** (Duplin): N. C. In *B. pyrum* of the modern fauna, the rounded outer lip begins early, the curvature being continuous from the sutural canal.

B. tuberculatum (Conrad) (**206**—18). Later whorls embracing only part way to angle; nodes flat and wide; spirals numerous; aperture more abruptly contracted. **Mioc.:** Md. (St. Marys).

B. maximum (Conrad) (**206**—20). Large; young whorls tubercled, adult whorls smooth, rounded; shoulder slightly concave. **Mioc.:** Va. and N. C. (Chesapeake). A more slender, elongate form (*B. rapum*) occurs in the Duplin of the Carolinas and the Choctawhatchee and Caloosahatchee of Fla.

B. tritone (Conrad) (**206**—14). Earliest whorls tubercled as in *B. tuberculatum*, intermediate smooth as in *B. maximum*, adult whorls regularly spinose on shoulder angle. **Mioc.:** Va. (Yorktown), N. C. (Duplin); **Plioc.:** N. C. (Waccamaw).

***B. caricum** (Gmelin). Large (length up to 223 mm, width 120 mm), with all whorls strongly spinose on shoulder angle, except earliest, which bear only round nodes. **Plioc.:** Carolinas; **Pleist.** and living of Atlantic Coast from Cape Cod to West Indies.

B. contrarium (Conrad) (**206**—19). Reversed; earliest whorls noded, adult smooth. **Mioc., Plioc.:** Carolinas (Duplin), Fla. (Caloosahatchee). Reversed species with character of *B. tritone* or *B. rapum* (*B. obrapum* Grabau) and one with charac-

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ters of *B. caricum* (*B. perversum*) occur in **Plioc., Recent** deposits of the Atlantic Coast.

SYCOTYPUS Browne 1756

(**Murex canaliculatus* Linnaeus). Like *Busycon* in form, but with canaliculate suture and typically without spines; tubercles of young often uniting into a smooth keel in adult. **Mioc.–Recent.**

S. rugosus (Conrad) (**206**—22, 23). Shoulder angle nodulated throughout, the nodes in adult becoming broad and subconfluent. **Mioc.** (Chesapeake): Md., Va.

S. excavatus (Conrad) (**206**—21). Outer lip of last whorl without shoulder angle and with sharp posterior notch. **Mioc.:** Carolinas (Duplin); **Plioc.:** S. C. (Waccamaw).

***S. canaliculatus** (Linnaeus). Young whorls nodulated; adult with more or less strongly developed carina. **Plioc.:** Carolinas; **Pleist., Recent:** Cape Cod to Gulf of Mexico.

HYDROTRIBULUS Wade 1916

(**H. nodosus*). Fairly low spiral angle; vigorous rugose, cancellate sculpture; body much inflated, inner lip much excavated and reflected, concealing an umbilicus. **U. Cret.** (*Exogyra costata* zone) (Atlantic and Gulf Coasts to Tex.).

***H. nodosus** Wade (**207**—1, 2). **Ripley:** Tenn.

BRUCLARKIA (Trask) Stewart 1926

(**Clavella gravida* Gabb). Canal comparatively wide, growth lines curved; three rows of nodes on body whorl. **Tert.**

***B. gravida** (Gabb) (**206**—17). Shell rather short and stout, spire conical with a collarlike shoulder at upper edge of last whorl; on greatest expansion of this whorl are three revolving rows of nodes with 12 to 14 nodes per row; growth lines broadly curved posteriorly; aperture ovate, outer lip simple; anterior canal curved. **M. Tert.:** Cal.

SEMINOLA Wade 1917

(**S. crassa*). Globose shells of different sizes having both spiral and axial sculpture variously developed; pillar broad and short, being separated from body by deep spiral sulcus that terminates with toothlike projection on margin of outer lip. **U. Cret.**

***S. crassa** Wade (**207**—17, 18). **U. Cret.:** Tenn. (Ripley), Tex. (Navarro).

BOLIS Gardner 1939

(**B. lisboa*). Buccinoid in form; whorls straight sided in adults and strongly shouldered by deep channeling of sutures; sculpture on adult whorls consisting of a few faint spiral and growth lines; columella thickened by a heavy callus which completely closes umbilicus; anterior canal short, truncated, and but very slightly recurved. **Eoc.** (Gulf Province).

***B. lisboa** Gardner (**207**—15, 16). **Eoc.** (Claiborne): Ala.

CANTHARUS "Bolten" Roeding 1798

(**C. globularis* = *Buccinum tranquebaricum* Gmelin). Bucciniform, but with anterior portion longer; aperture and spire of about equal length; sculpture of spiral riblets and axial undulations; inner side of outer lip crenulated; columella nearly smooth or with a few small ridges. **Pleist.**

C. (**Calicantharus**) **fortis** (Carpenter) (**207**—14). **Pleist.:** Cal.

BUCCINUM Linnaeus 1758

(**B. undatum*). Stout inflated shells, smooth or ribbed and spiraled; spire short, aperture wide, anterior canal short; outer lip sharp, thin, smooth; inner lip with callus. **Tert.–Recent.**

B. plectrum Stimpson (**207**—5). **Mioc.:** St. Paul Island; Unalaska; Unga Island; **Recent:** Point Barrow, Arctic Ocean, south to Puget Sound; circumboreal.

TYPHIS Montfort 1810

(**Murex tubifer* Bruguière). Like *Murex*, but varices are riblike, spines are tubes and less regular, and short anterior canal is completely closed. **Cret.–Recent.**

T. curvirostratus Conrad (**207**—10). Spire somewhat lower than in *T. acuticosta*; sides of whorls more nearly straight; ribs strong and ending in vertical spines; aperture small and round; anterior beak strongly curved. **Olig.** (Vicksburg): Miss.

T. acuticosta Conrad (**207**—11, 12). Whorls with four to five varices ending at shoulder angle in compressed spines, alternating with four shorter, rounded varices ending in hollow spines or tubes; rostrum slightly reflected. **Mioc.** (Chesapeake): Md.

T. obesus Gabb. Short and broad with low spire; whorls sharply angulated, concave above and convex below suture; four varices per whorl, acute-angular on margins and ending in blunt process on upper angle of whorl; shell swollen at base of tubular spines; surface polished, with few spirals. **Mioc.:** Dominican Republic; Canal Zone; Jamaica (Bowden); Fla. (Chipola).

PLATE 207

[Figures are x1 unless otherwise indicated.]

1, 2. Hydrotribulus nodosus [USGS, PP 137]. Type. **3, 4. Urosalpinx cinerea** [Md G S, Mioc]. Views of two specimens. **5. Buccinum plectrum** (x1.8) [USNM, Pr 24]. **6, 7. Neptunea spp. 6. N. (Neptunea) lirata** (x0.9) [USGS, PP 59]. **7. N. (Sulcosipho) tabulata** (x0.8) [USNM, Pr 24]. **8, 9. Sargana stantoni** [U Tex Pub 4101; print furnished by L. W. Stephenson]. Two views of holotype (x1.5). **10–12. Typhis spp. 10. T. curvirostratus** [Ac N Sc Phila, J (2) 1]. **11, 12. T. acuticosta** [Md G S, Mioc]. **13. Murex mississippiensis** [Ac N Sc Phila, J (2) 1]. **14. Cantharus (Calicantharus) fortis** [San Diego Soc N H, M 1]. **15, 16. Bolis lisboa** [USGS, PP 193]. Holotype and a paratype. **17, 18. Seminola crassa** [USGS, PP 137]. Two views of type.

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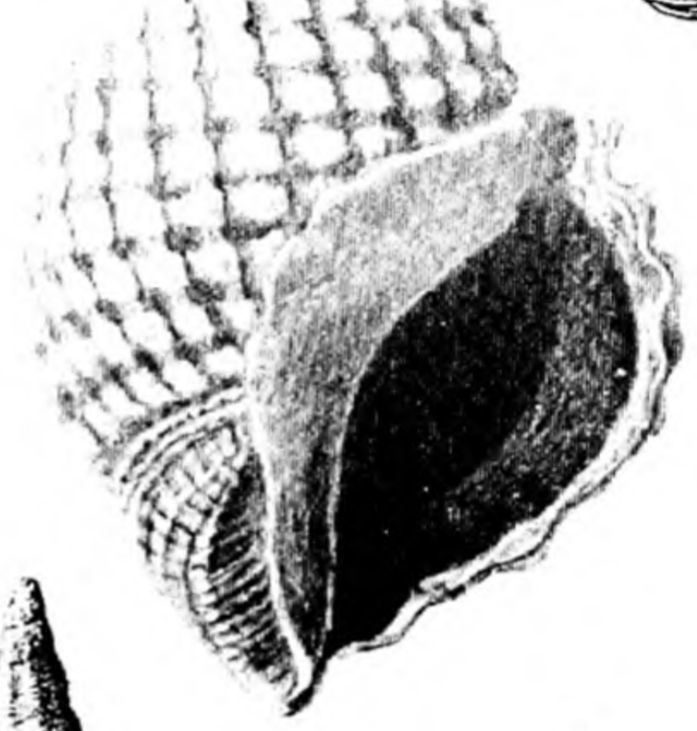

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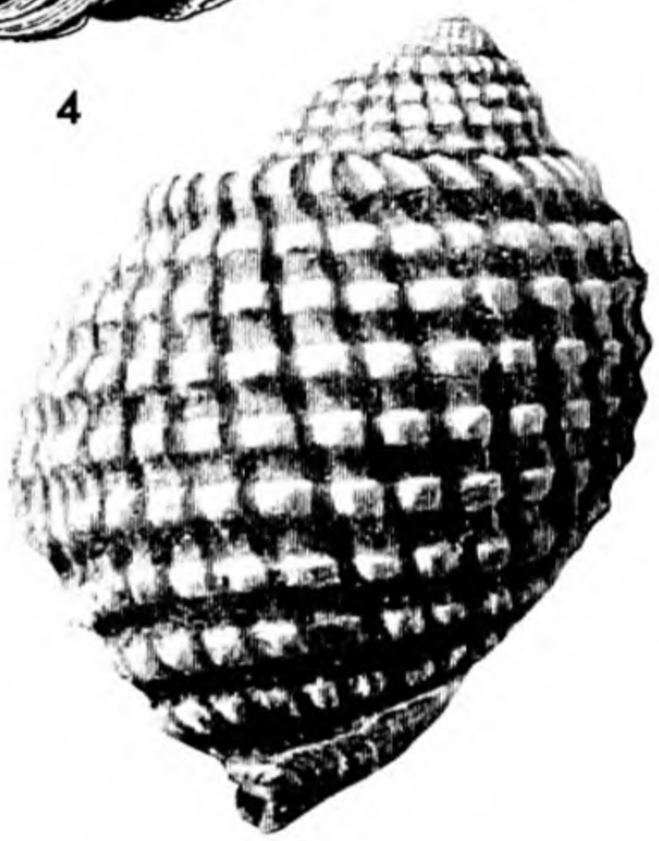

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SARGANA Stephenson 1923
(= RAPANA Weller 1907)

(**Rapana stantoni* Weller). Distinguished by its low, almost flat spire; broad, deep spiral sulcus which emerges from beneath inner lip about midway of aperture and extends to lower end of outer lip; and a pronounced fold or ridge at angle separating columella from canal. **U. Cret.**

***S. stantoni** (Weller) (**207**—8, 9). **U. Cret.** (*Exogyra costata* zone of Atlantic and Gulf Coastal Plains): N. J. (Matawan), N. C. (Peedee), Tenn. (Ripley), Ga. (Ripley), Tex. (Navarro).

UROSALPINX Stimpson 1865

(**Fusus cinereus* Say). Short and thick fusiform shells with spire of few regularly enlarging whorls, and with an anterior canal of moderate length, often slightly bent; aperture pyriform, outer lip often denticulate; surface with ribs and spirals; the common "oyster drill." **Tert.–Recent.**

***U. cinerea** (Say) (**207**—3, 4). Whorls rounded, rarely with shoulder flattening; no angulation, ribs narrow, round and distant, becoming obsolete above and below, often wanting on body whorl; spirals numerous, not coarse, in several cycles. **Pleist.:** Atlantic Coast of U. S. A.; **Recent:** Prince Edward Island, Canada, to Fla.

MUREX Linnaeus 1758

(**M. pecten* Montfort = *M. tribulus* Linnaeus). Genus includes several distinct genetic series and is to be considered a "form genus"; whorls round or angular, shell fusiform with spire ribbed and with spirals; aperture drawn out anteriorly into a straight or curved canal; outer lip expanded into a varix with or without simple or compound spines; varices of former aperture persistent, three or more per volution. **Cret.?, Tert.–Recent.**

M. mississippiensis Conrad (**207**—13). Small, with three nonspinous varices and often with two or more faint, rounded ribs between varices; spirals compound, strong, often crowded; canal strongly deflected, very narrow. **Olig.:** Miss. (Vicksburg).

NEPTUNEA "Bolten" Roeding 1798

(**Murex antiquus* Linnaeus). Shell moderately large, elongated-oval to subfusiform, ventricose; sculpture mostly spiral; outer lip usually simple; anterior canal moderately long, slightly curved. **Cret.–Recent.**

N. (Neptunea) lirata (Martyn) (= **Cymatium pacificum** Dall) (**207**—6). Shell typically with sloping tabulation on upper part of whorls and with strong, square spiral ridges separated by wide interspaces, varying into forms with low sculpture and with incipient interribs. **Mioc.:** Wash. (Montesano), Ore. (Empire); **Plioc.:** Ore. (Coos); **Pleist.:** Juneau Harbor, Alaska; **Recent:** Icy Cape, Arctic Ocean, south to Pugent Sound on east and to Japan on west; off California coast.

N. (Sulcosipho) tabulata (Baird) (**207**—7). Characterized by rather uniform spiral ribbing, prominent tabulation bordered by a raised ridge on upper part of each whorl, and rather wide, strong anterior canal. **Mioc.:** Wash., Ore. (Empire), Cal.; **Plioc.:** Ore., Cal.; **Pleist.:** Cal.; **Recent:** B. C. to S. Cal.

BARBAROFUSUS Grabau and Shimer 1909

(**Fusus barbarensis* Trask). Like *Heilprinia*, but more loosely coiled, with larger spire and less contracted aperture. **Tert.**

***B. barbarensis** (Trask) (**208**—1). Thin-shelled, slender, with long spire, clear spiral sculpture crossing axial ribs, and a long anterior canal. **Plioc.–Recent:** Ore., Cal.

TRITIARIA Conrad 1865

(**Buccinum mississippiensis*). Small, spire rather high, with distant narrow ribs and raised alternating spirals; outer lip lirate within; columella striate. **Eoc., Olig.** (Gulf Coast).

***T. mississippiensis** (Conrad) (**208**—2). **Vicksburg:** Miss.

ECPHORA Conrad 1843

(**E. quadricostata* = *Fusus 4-costatus* Say). Large, short and thick shells, rather loosely coiled toward last, leaving wide umbilicus; aperture more or less pyriform, extended into short anterior canal; surface marked by coarse spiral folds, rarely by finer spirals. **Cret.–Mioc.**

***E. quadricostata** (Say) (**208**—3). Adult shell deeply umbilicated, with four very prominent projecting spiral folds, often T-shaped in section, less prominent and somewhat noded in young; var. **umbilicata** (Wagner) (**208**—4) has larger umbilicus looser coil, thinner and not T-shaped spirals; **E. tricostata** Martin (**208**—5) has lower spiral weak or absent. **U. Mioc.:** Atlantic Coast, Md. through Fla.

MOREA Conrad 1860

(**M. cancellaria*). Short-elliptical; aperture much

PLATE 208

[Figures are x1 unless otherwise indicated.]

1. Barbarofusus barbarensis (x1.5) [Cal Ac Sc, M 3]. **2. Tritiaria mississippiensis** [Ac N Sc Phila, J (2) 1]. **3–5. Ecphora** spp. [Md G S, Mioc]. **3. E. quadricostata. 4. E. quadricostata umbilicata. 5. E. tricostata. 6, 7. Morea cancellaria** [USGS, PP 137]. Two views of shell (x2). **8–11. Fasciolaria** spp. **8. F. rhomboidea** (x2) [Fla G S, B 3]. **9. F. (Cryptorhytis) utahensis** [USGS, B 106]. **10, 11. F. (Plestochilus) culbertsoni** [USGS Ter 9]. Imperfect specimen, and back view of type. **12. Latirus floridanus** [Wag Free Inst Sc, Tr 3 (1)]. **13. Latirus (Peristerina) filicatus** [Fla G S, B 3]. **14, 15. Heilprinia** spp. (x0.8) [Wag Free Inst Sc, Tr 3 (2)]. **14. H. equalis. 15. H. caloosaënsis. 16. Falsifusus meyeri** [B Am Pal 3 (11)]. **17. Anomalofusus substriatus** [USGS, PP 137]. Back view of type. **18. Ornopsis glenni** [USGS, PP 137]. **19, 20. Fulgurofusus** spp. **19. F. henekeni** [QJGS 32], Apertural view of type. **20. F. quercollis** [B AM Pal 1 (4)]. **21, 22. Hercorhynchus malleiforme** [U Tex Pub 4101; print furnished by L. W. Stephenson]. Holotype.

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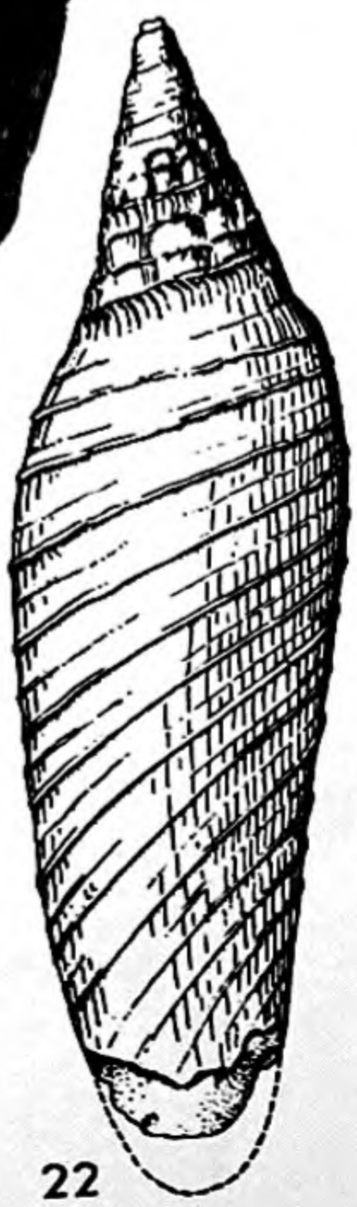

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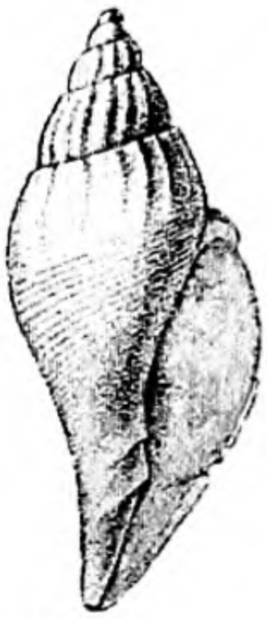

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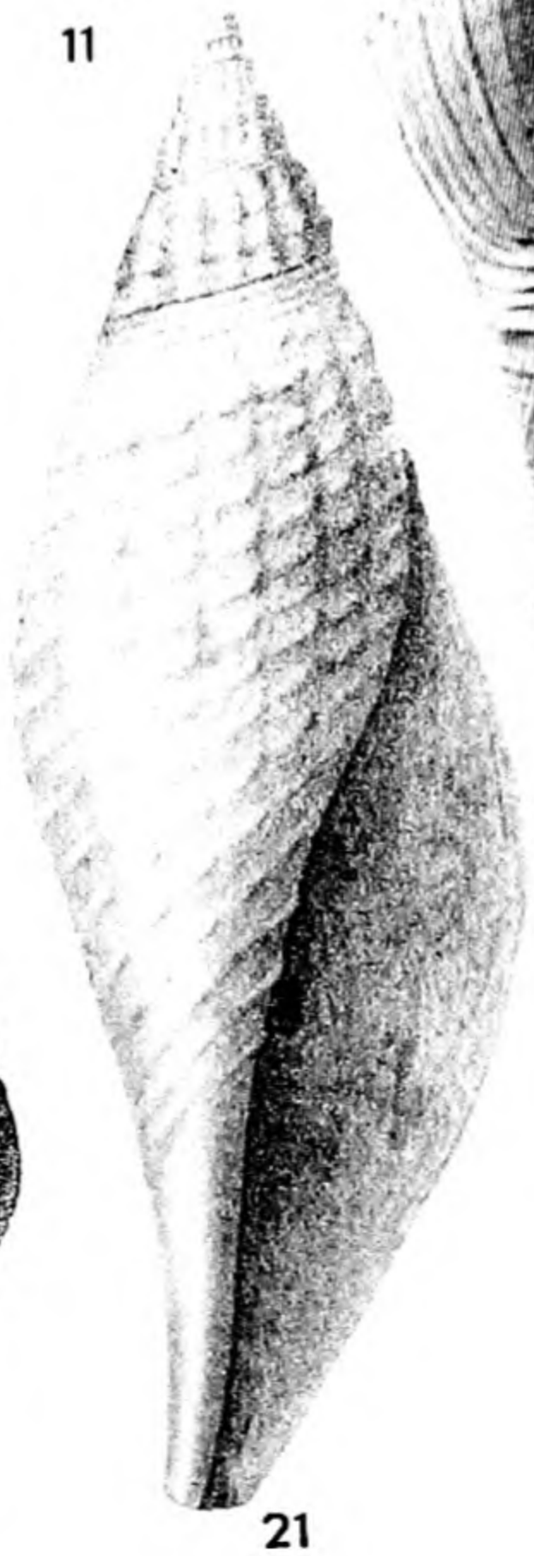

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longer than spire; columella reflexed, concave, with a prominent acute fold at base. **U. Cret.**

***M. cancellaria** Conrad (**208**—6, 7). **Ripley:** Tenn., Ala., Miss.

FASCIOLARIA Lamarck 1799

(**Murex tulipa* Linnaeus). Protoconch and young whorls typically fusoid, later whorls ribbed and spiraled with a sharp angulation and flat shoulder or with rounded whorls; canal shorter than in *Busycon* and spire longer; columella with two to three oblique plications in anterior end, in typical forms with a strong, oblique anterior angulation. **Cret.–Recent.**

F. (Cryptorhytis) utahensis (Meek) (**208**—9). Whorls embracing to shoulder angle, shoulder of later whorls flat, earlier ones rounded; ribs faint or condensed to tubercles; body whorl gradually contracting to slightly bent canal; columella with one strong fold so far back that is it hardly visible in a perfect specimen. **U. Cret.** (Coloradoan, Pugnellus zone): Colo., Utah.

F. (Piestochilus) culbertsoni Meek and Hayden (**208**—10, 11). Whorls round, suture scarcely impressed; surface with rounded, low ribs which become obsolete in adult of many specimens; spirals uniform; one to four plaits on columella, not visible at aperture. **U. Cret.:** Dakotas (Fox Hills).

F. rhomboidea Rogers (**208**—8). **U. Mioc.:** Va. (Yorktown), Carolinas (Duplin), Fla. (Choctawhatchee).

HERCORHYNCHUS Conrad 1869

(**Fusus tippana*). Fusiform; whorls seven, concave above; angle near and above suture salient and tuberculated; spirals obsolete on spire but prominent on body whorl, which is carinated. **U. Cret.**

H. mallaeforme Stephenson (**208**—21, 22). **U. Cret.** (*E. costata* zone): Miss., Tex. (Navarro).

HEILPRINIA Grabau 1904

(**Fusus caloosaensis* Heilprin). Fusoid shells with protoconch ribbed throughout; body whorl more or less abruptly contracted into the canal; columella usually plicate in adult; outer lip commonly lirate. **Mioc.–Recent.**

***H. caloosaensis** (Heilprin) (**208**—15). Shoulder of later whorls flat but angle not pronounced; ribs faint on later whorls; spirals mostly primary, more rarely fine secondary ones intercalated; aperture and whorl abruptly contracted to slender canal, which is slightly sinuous; inner lip strong, multiplicate; outer strongly lirate. **Plioc.** (Caloosahatchee): Fla.

H. equalis (Emmons) (**208**—14). Differs from the preceding in having last whorls free from indication of ribs, well rounded, and strongly marked by spirals; both outer and inner lip strongly lirate on apertural side. **Mioc.:** N. C.

FULGUROFUSUS Grabau 1904

(**Fusus quercollis* Harris). Fusoid; protoconch oblique and without ribs, merging into an angulate conch which throughout has concave or flat shoulders and a sharp, nodose peripheral keel. **Tert.**

***F. quercollis** (Harris) (**208**—20). Carina with sharp, flat nodes; spirals faint; sutures very deep. **Paleoc.** (Midway): Ala.

F. henekeni (Sowerby) (**208**—19). Whorls round, rather closely embracing, with stout round ribs and simple spirals, with intercalated secondary ones in later whorls. **Mioc.:** San Domingo.

FALSIFUSUS Grabau 1904

(**Fusus ottonis* Aldrich = *Falsifusus meyeri* Aldrich, not *F. meyeri* Dunker). Fusoid, with protoconch consisting of numerous gradually enlarging, smooth whorls merging into conch, whorls of which early become angular. **Paleoc., Eoc.**

***F. meyeri** Aldrich (**208**—16). Whorls angular almost throughout; ribs and simple spirals continue to lip; spire and canal of equal length, very slender. **Paleoc.** (Midway): Gulf States.

ORNOPSIS Wade 1916

(**O. glenni*). Apex pointed, body much inflated; characterized by peculiar narrow flexed canal and sharp laminar plait on columella directly behind entrance of anterior canal. **U. Cret.** (Tenn., Tex.).

***O. glenni** Wade (**208**—18). **Ripley:** Tenn.

ANOMALOFUSUS Wade 1916

(**Fusus* (*Anomalofusus*) *substriatus*). Differs from *Fusus* in its nuclear characters, shorter canal, and thickened and notched outer lip. **U. Cret.** (Tenn., Tex.).

***A. substriatus** Wade (**208**—17). **Ripley:** Tenn.

LATIRUS Montfort 1810

(**L. aurantiacus* = *Murex filosus* Lamarck = *Murex gibbulus* Gmelin). Fusiform, with straight and fairly short canal; columella with two to three plaits anteriorly; sometimes umbilicated; whorls with ribs and spirals; outer lip lirate within; generally angulated. **Cret.–Recent** (eastern coast of N. America).

PLATE 209

[Figures are x1 unless otherwise indicated.]

1, 2. Lyria pycnopleura [USGS, PP 137]. Holotype (x2); tip of a paratype greatly enlarged (x10). **3–7. Volutocorbis** spp. **3–5. V. petrosus** [Md G S, Eoc]. A young specimen and two views of a mature shell. **6. V. rugatus** [B Am Pal 1 (4)]. **7. V. limopsis** [B Am Pal 1 (4)]. **8. Caricella pyruloides** (x0.7) [Conrad: Fos Shells Tert Fm 1 (2)]. **9. Xancus chipolanus** [Wag Free Inst Sc, Tr 3]. Young shell with decollate nucleus (x1.2). **10, 11. Aurinia mutabilis** [Fla G S, B 3; Md G S, Mioc]. **12, 13. Lapparia dumosa** [B Am Pal 7 (32)]. Two shells (x1.5). **14, 15. Liopeplum leioderma** (x2) [USGS, PP 137]. **16–22. Volutoderma** spp. **16, 17. V. dalli** [USGS, B 106]. Two views of specimen (x0.7). **18, 19. V. ambigua** (x0.7) [USGS, B 106]. **20. V. protracta** [USGS, PP 137]. **21. V. averillii** [Pal Cal 1]. **22. V. texana** (x0.7) [SMC 50]. **23. Volutomorpha mutabilis** [USGS, PP 137].

L. floridanus Heilprin (**208**—12). Whorls round but shoulder flattened; ribs dying away toward suture; spirals pronounced with very fine secondary ones; lirae strong; columella with two obscure plaits; outer lip with additional lirae in adult specimens. **Mioc.:** Fla. (Tampa).

L. (Peristerina) filicatus (Conrad) (**208**—13). **U. Mioc.:** Va. and N. C. (Chesapeake), Fla. (Choctawhatchee).

LYRIA Gray 1847

(**Voluta nucleus* Lamarck). Like *Volutocorbis* in general character, but axial sculpture is less sharp and labrum is not lirate within. **Tert.–Recent** (worldwide distribution). (It may be that the Eocene species commonly referred to *Voluta* belong here; true *Voluta* may not have differentiated until later.)

L. pycnopleura Gardner (**209**—1, 2). **Mioc.:** Fla. (Chipola).

VOLUTOCORBIS Dall 1890

(**Volutilithes limopsis* Conrad). Spinose volutids commonly referred in earlier publications to *Volutilithes*. **L. Tert.**

***V. limopsis** (Conrad) (**209**—7). Like *V. rugatus*, but with more numerous, narrower, and sharper ribs cancellated and spinulated by strong, sharp spirals, especially marked on ribs. **Paleoc.** (U. Midway): Ala. to Tex.

V. rugatus (Conrad) (**209**—6). Whorls round, with rounded, strong and rather distant ribs crossed by compound spirals; callus of inner lip reaching only part way over whorl; columella with three folds, middle obsolete. **Paleoc.** (Midway): Ala. to Tex.

V. petrosus (Conrad) (**209**—3–5). Young shell fulguroid, whorls embracing to angle, which is spinose, the spines continued downward as ribs; shoulder changing from round to concave; in adult whorls more irregular; last whorl like strong spines on angle; callus of inner lip large, covering part of whorl and shoulder; presence of earlier calluses indicated on shoulder of preceding whorls; columella with three plications. **Eoc.** (U. Claiborne and Jackson): Ala. to Tex.

LAPPARIA Conrad 1855

(**Mitra dumosa*). Volutids with mitroid form; embryonic whorl as in *Caricella*. **Eoc.** (Claiborne and Jackson of Mississippi Embayment).

***L. dumosa** (Conrad) (**209**—12, 13). **Jackson** of the Mississippi Embayment.

VOLUTA Linnaeus 1758

(**V. musica*). "Form genus" applied to fusiform or fulguroid shells with moderate spire of angulated (except earliest) whorls, ribbed and generally tubercled on angle; adult whorls smooth in certain forms; aperture narrow, canaliculate behind; inner lip often with thin callus; columella with numerous plaits of varying strength. **Tert.–Recent.**

The volutid gastropods were long comprehended in the Linnaean genus VOLUTA, later in VOLUTILITHES Swainson 1831. (**V. muricina* Lamarck); now, however, they are distributed among numerous "superspecific" groups: VOLUTODERMA Gabb 1876 (**Volutilithes navarroensis* Gabb not Shumard = *Fusus averillii* Gabb), and VOLUTOMORPHA Gabb 1876 (**Volutilithes conradi*) are typically U. Cretaceous. VOLUTOCORBIS Dall 1890 (**Volutilithes limopsis* Conrad), VOLUTOSPINA Bullen-Newton 1906 (**Conus spinosus* Linnaeus), and LAPPARIA Conrad 1855 (**Mitra dumosa*) are typically L. Tert.

***V. musica** Linnaeus. Protoconch many whorled, round, increasing regularly; later whorls with spirals; early conch whorls round with round ribs, later ones ribbed and subsequently noded; last whorl with strong nodes bounding concave shoulder; columellar plications numerous; surface marking chiefly in lines and spots resembling musical notes. **Plioc.:** Costa Rica; **Recent:** West Indies.

CARICELLA Conrad 1835

(**Turbinella pyruloides*). Like *Aurinia*, but with four strong columellar plaits. **Eoc.**

***C. pyruloides** (Conrad) (**209**—8). Pyriform, smooth, spire low, shoulder flat; body whorl rounded, tapering regularly to anterior end; columellar plaits four, distant and oblique. **Eoc.:** Ala. (U. Claiborne).

AURINIA H. Adams and A. Adams 1853

(**A.* (*Voluta*) *dubia* Broderip). Like *Voluta*, but generally with rounded adult whorls which are free from ribs or spirals; outer lip regularly curved. **Tert., Recent.**

A. mutabilis (Conrad) (**209**—10, 11). Long and rather slender; last two or more whorls smooth, but with concave shoulder; angle rounded; aperture long, canal somewhat curved; plicae three, two strong and a fainter one between. **Mioc.** (Chesapeake): Md. to N. C.; N. and S. C. (Duplin); Fla. (Choctawhatchee).

XANCUS "Bolten" Roeding 1798

(= TURBINELLA Lamarck 1799)

(**Voluta pyrum* Gmelin). Similar to *Clavilithes*, but generally without shelf and with strong columellar folds; protoconch long and papillose; a distinct shoulder occurs in some species, with ribs noded on angle; last whorl generally smooth, but may retain ribs and nodes as irregular folds. **Cret.–Recent.**

X. chipolanus (Dall) (**209**—9). Young whorls (two to three) with coarse ribs which become obsolete later on; last whorl round; intercalated spirals between strong primary ones; columella with three oblique folds; protoconch cylindrical, of many whorls. **Mioc.:** Fla. (Chipola).

LIOPEPLUM Dall 1890

(= LIODERMA Conrad 1865)

(**Volutilithes* (*Athleta*) *leioderma* Conrad). Generic characters and range given under genotype.

***L. leioderma** (Conrad) (**209**—14, 15). Subfusiform, smooth, polished; spire elevated but height much less than length of aperture; four to five whorls; shoulder over aperture with projecting callus; aperture long, broadly lenticular, produced in front into a short open canal, marked at posterior commissure by a shallow, angular siphonal notch; outer lip thin and simple; columella strong, marked by two distinct but feeble plaits. **U. Cret.:** Md. (Monmouth), Tenn. and Miss. (Ripley); varieties in Navarro of Tex.

VOLUTODERMA Gabb 1876

(**Volutilithes navarroensis* Gabb not Shumard = *Fusus averillii* Gabb). **U. Cret.**

***V. averillii** (Gabb) (**209**—21). Easily recognized by shape and surface ornamentation. **U. Cret.** (Chico): Wash., Cal.

V. texturata (Whitfield). With short spire and very long, slender body whorl forming almost entire length; aperture long and narrow; surface marked by strong spirals and weaker liplike ridges, which sometimes node the spirals. **U. Cret.** (Ripley): N. J., Ala., Miss.

V. dalli (Stanton) (**209**—16, 17). Spire moderate; shoulder concave; angle with nodes which continue downward as ribs for short distance; early whorls rounded and ribbed; spirals numerous and compound; canal nearly straight. **U. Cret.** (Coloradoan): Colo. (Pugnellus zone), N. Mex.

V. ambigua (Stanton) (**209**—18, 19). Whorls round but not bulging; sutures moderately depressed; earlier whorls with regular, somewhat oblique ribs rather close together; body whorl with ribs only near suture; canal slightly curved; two strong oblique plications on columella, with faint indication of others. **U. Cret.** (Coloradoan): Kan. (Benton), Colo. (Pugnellus zone).

V. protracta (Dall) (**209**—20). **U. Cret.:** Ripley of Tenn., Miss.; Navarro of Tex.

V. texana (Conrad) (**209**—22). **U. Cret.:** Tex. (Navarro).

VOLUTOMORPHA Gabb 1876

(**Volutilithes conradi*). Generic characters illustrated by genotype. **U. Cret.**

***V. conradi** (Gabb). Rather large; spire moderate, of rounded whorls with impressed suture, sometimes a slight subsutural flattening; body whorl four-fifths of length, varying in convexity, but contracted to short anterior canal; ribs narrow, far apart, cancellated by strong spirals; internal fillings commonly smooth. **U. Cret.:** N. J. (Magothy, Monmouth), Md. (Monmouth).

V. mutabilis Wade (**209**—23). **Ripley:** Tenn.

FUSIMITRA Conrad 1855

(**Mitra millingtoni*). Shell slender, with strong spiral sculpture; body whorl becomes constricted, with concave area, at posterior line of aperture; basal portion of aperture canaliculate. **Tert.**

F. polita (Gabb) (**210**—1). **Eoc.:** Tex. (L. Claiborne).

CONOMITRA Conrad 1865

(**Mitra fusoides* Lea). Like *Fusimitra*, but with lower spire. **Tert.**

***C. fusoides** (Lea) (**210**—2, 3). **Eoc.:** Ala. (Gosport).

C. staminea (Conrad) (**210**—4). Spire and aperture about equal; whorls rounded; suture moderately depressed; ribs faint; columella with four plications. **Olig.** (Vicksburg): Miss.

MITRA Martyn 1784

(**M. tessellata*). "Form genus" with numerous subgenera; shell fusiform, spire elevated, protoconch commonly polygyrate; sculpture axial or spiral, surface smooth; suture impressed usually; aperture narrow, commonly half shell length; outer lip sharp-edged; columella bearing three to five folds, which increase in prominence posteriorly; anterior extremity emarginate or truncate. **Tert.–Recent.**

M. acteoglypha Gardner (**210**—9). **Mioc.:** Fla. (Chipola).

VEXILLUM "Bolten" Roeding 1798

(**V. plicatum* Roeding = *Voluta plicaria* Linnaeus). Characterized by slender, turriculate spire; dominantly axial ornamentation, distinct anterior canal, and truncate very obscurely emarginate anterior extremity. **Tert.–Recent.**

V. (Uromitra) (triptum) Gardner (**210**—17). **M. Mioc.:** Fla. (Shoal River).

MARGINELLA Lamarck 1799

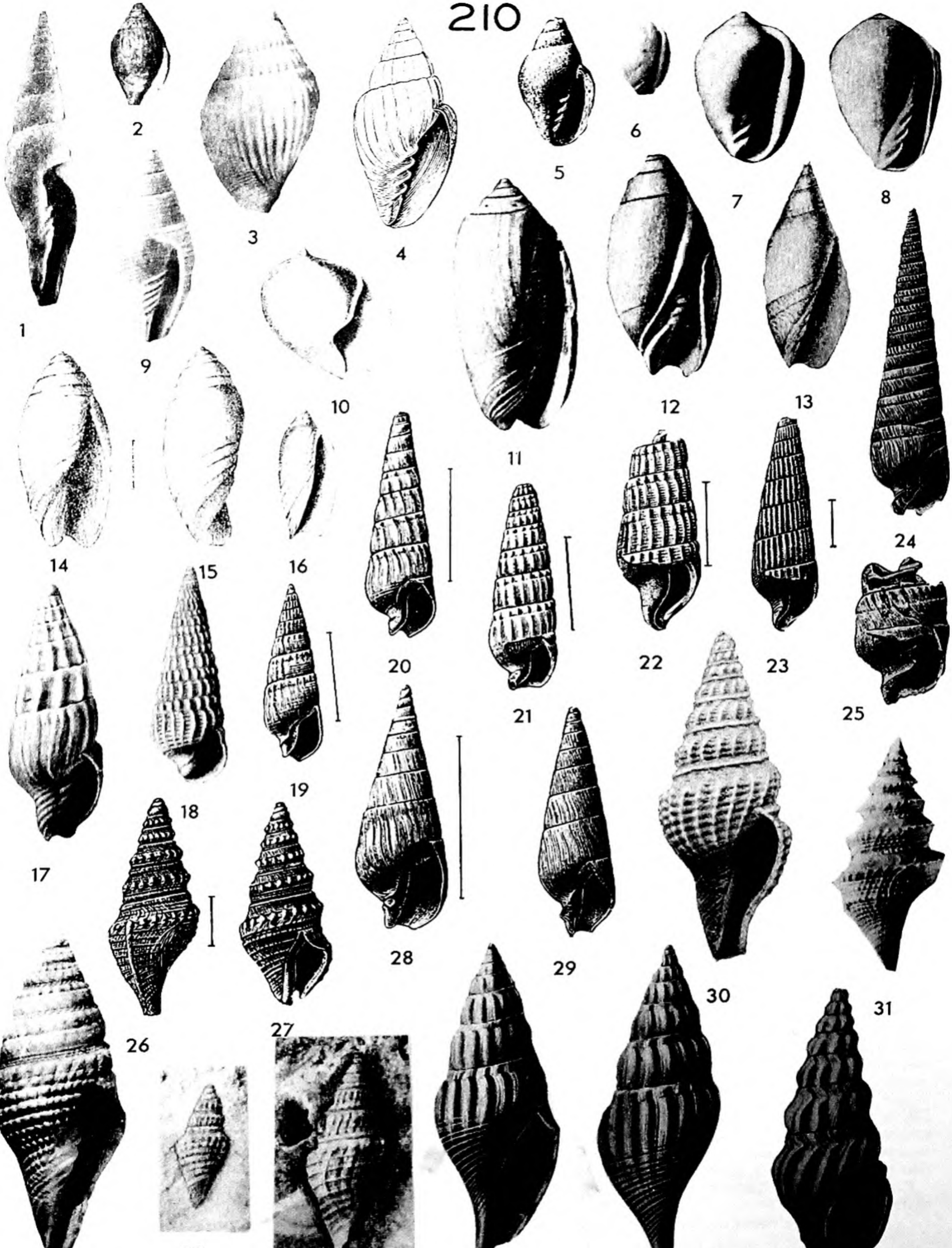
(**Voluta glabella* Linnaeus). Oval or long shells with smooth exterior, elevated spire and elongate aperture, which is slightly canaliculate anteriorly; three to four equal oblique folds on columella; outer lip often thickened and dentate. **Eoc.–Recent.**

M. (Egouena) virginiana Conrad (**210**—6). Spire low but not sunken; body whorl tapering forward, giving shell aspect of *Conus*. **Mioc.–Recent.:** Chesapeake of Va. and N. C.; Duplin and Waccamaw of N. C.; Caloosahatchee of Fla.; **Recent** of coast of N. America from N. C. to Yucatan.

M. limatula Conrad (**210**—7). Small, with low spire and apertural part of last whorl reaching up and bending over on spire; four plications near base of columella; outer lip denticulate within; aperture widening regularly forward. **Mioc.** of Va. to Fla.; **Plioc.** and **Pleist.** of Carolinas and Fla.; **Recent** off Carolina coast.

M. denticulata Conrad (**210**—5). Small; spire high for genus, of about five regularly enlarging whorls, nearly flat, with suture slightly depressed; body whorl narrowing toward front; aperture narrow and ovoid, widest in middle, with four strong plicae on columella and denticulations on outer lip; no anterior notch. **Mioc.:** Chesapeake of Md. and N. C.; Caloosahatchee of Fla.; **Recent** from Cape Hatteras to Fla. and Barbados.

M. minuta Pfeiffer (**210**—8). **Mioc.:** Fla. (Choctawhatchee).



ANCILLOPSIS Conrad 1865

(**Ancillaria altilis*). Subglobular; spire short, body whorl large, inner lip with strong callus; differs from *Ancilla* [not described here] chiefly in its subglobose form. **Eoc.**

A. subglobosa Conrad (**210**—10). Apex sharply pointed; suture obsolete; columella with profound callus projecting in middle. **Eoc.** (Claiborne): Ala.

OLIVULA Conrad 1832

(**Ancillaria staminea*). Vertically striate, *Oliva*-like shells with somewhat channeled suture. **Tert.**

***O. staminea** (Conrad) (**210**—16). An impressed line just below suture constricts off a subsutural band; aperture rather broad posteriorly; columella anteriorly with striated callus; surface with strong vertical, and faint revolving lines. **Eoc.** (Claiborne): Gulf Province (**O. staminea** *ss* is from U. Claiborne; var. **punctulifera** (Gabb) from L. Claiborne).

O. marysvillensis Dickerson (**210**—14, 15). **Eoc.:** Cal.

OLIVELLA Swainson 1831

(**Oliva purpurata* Swainson = *O. dama* Mawe). Distinguished from *Oliva* by smaller size, thinner shell, more produced spire, and presence of horny operculum. **Tert.–Recent.**

O. (**Agaronia**) **alabamensis** (Conrad) (**210**—13). Spire acute, elevated, whorls scarcely round and suture faintly impressed, a notched spiral above suture; aperture rather broad; notched band near base of body whorl. **Eoc.:** Ala. (Claiborne). (Abundant and variable, especially in spire length.)

O. mutica (Say) Dall (**210**—12). **U. Mioc.:** N. and S. C. to Fla.; **Plioc.:** Fla.; **Pleist.–Recent:** N. C. to Tex. and West Indies.

OLIVA Martyn 1786

[Neave lists Bruguière 1789 as author]

(**O. corticata*). Shell of subcylindrical form, smooth and shining, with short spire and long body whorl; sutures sharply depressed; aperture narrow; columella with oblique folds. **Cret.–Recent.**

O. sayana Ravenel (= **O. litterata** Lamarck) (**210**—11). Slightly inflated above middle; suture canaliculate; columella plaited throughout. **Mioc.:** N. J., Md., N. C., Fla.; San Domingo; Jamaica; **Plioc.** Carolinas, Fla. (Caloosahatchee); **Pleist.:** S. C., Fla.; **Recent** off N. C. to Gulf of Mexico and West Indies.

TEREBRA Bruguière 1789, Lamarck 1799

(**Buccinum subulatum* Linnaeus). Shell usually high spired, whorls regularly enlarging, body whorl not inflated; aperture with short, curved canal, generally sharp or slightly canaliculate posteriorly; surface of whorls smooth or ribbed; a depressed spiral occurs a short distance below suture constricting off a subsutural band, which is weak or absent in *Acus*. **Tert.–Recent.** (*Terebra ss* is a tropical genus.)

"T." unilineata Conrad (**210**—24, 25). Constricting spiral prominent, the space between it and suture above being marked by short, oblique riblike undulations generally wanting in older whorls; surface otherwise smooth, except for oblique growth lines. **Mioc.** (Chesapeake): Md., N. C.

"T." (Acus) curvilineata Dall. Shorter and less tapering spire than *"T." unilineata*, whorls with vertical ribs, the subsutural depressed spiral faint or obsolete; in var. **whitfieldi** Martin (**210**—22, 23) ribs are strong but narrow and vertical, while fine sharp spirals mark spaces between ribs; aperture narrow; in var. **dalli** Martin (**210**—19) ribs are obsolete except just below suture; in var. **calvertensis** Martin (**210**—21) the subsutural depressed spiral is rather strong, the ribs being nodulated upon band thus produced. **Mioc.** (Chesapeake: Md.

T. (Acus) curvilirata Conrad (**210**—20). Ribs curving backward and slightly nodose on subsutural band. **Mioc.** (Chesapeake): N. J., Md.

T. (Strioterebrum) dislocata (Say) (**210**—18). **Mioc.:** Va., N. C.; **Plioc.:** Carolinas, Fla., Cal.; **Pleist.:** Md. southward; Cal.; **Recent:** Md. to Fla.; Bahamas; Venezuela.

HASTULA H. Adams and A. Adams 1853

(**Buccinum strigilatum* Linnaeus [in sense of later authors — see Woodring 1928, 143]). Shell small, whorls flat, aperture wide; anterior canal short, notched; siphonal fasciole wide, medially grooved; boundary of fasciole forming an overlapping shelf; columella bearing an obscure basal fold; parietal wall covered with callus; surface with narrow axial ribs that disappear on anterior part of whorls. **Eoc.–Recent.**

PLATE 210

[Figures are x1 unless otherwise indicated.]

1. Fusimitra polita [B Am Pal 7 (32)]. A large shell (x1.5). **2–4. Conomitra spp. 2, 3. C. fusoides** [B Am Pal 7 (32)]. A shell enlarged (x4); type (x2). **4. C. staminea** (x2.6) [Wag Free Inst Sc, Tr 3]. **5–7. Marginella spp. 5. M. denticulata** (x5) [Md G S, Mioc]. **6. M. (Egouena) virginiana** (x2) [USGS, PP 142]. **7. M. limatula** (x2) [USNM, B 90]. **8. M. minuta** (x10) [Fla G S, B 3]. **9. Mitra acteoglypha triptum** [USGS, PP 142]. Holotype (x6). **10. Ancillopsis subglobosa** (x0.7) [Conrad: Fos Shells Tert Fm 1 (2)]. **11. Oliva sayana** [Fla G S, B 3]. [USGS, PP 142]. Holotype (x2). **12, 13. Olivella spp. 12. O. mutica** (x6) [Fla G S, B 3]. **13. O. (Agaronia) alabamensis** [Conrad: Fos Shells Tert Fm 1 (3)]. **14, 15. Olivula marysvillensis** (x4) [U Cal Pub, Dp G 7]. **16. Olivula staminea** (x0.6) [Conrad: Fos Shells Tert Fm 1 (2)]. **17. Vexillum (Uromitra) dalli** [Md G S, Mioc]. **20. T. (Acus) curvilirata** [Md G S, Mioc]. **21. T. (Acus) curvilineata calvertensis** [Md G S, Mioc]. **22, 23. T. (Acus) curvilineata whitfieldi** [Md G S, Mioc]. **24, 25. T. unilineata** [Md G S, Mioc]. Complete specimen and apertural view of a fragment. **26, 27. Coronia childreni** [Md G S, Eoc]. Apertural view of a broken shell; back view of another more complete specimen. **28, 29. Hastula spp.** [Md G S, Mioc]. **28. H. simplex sublirata. 29. H. simplex. 30. Crassispira calligona** (x3) [USGS, PP 142]. **31. Cochlespira cristata** [Pal Americana 2 (7)]. **32–34. Scobinella spp. 32. S. coelata** [Pal Americana 2 (7)]. **33, 34. S. claytonensis** [Ac N Sc Phila, Pr 78]. **35, 36. Drilluta communis** [USGS, PP 137]. Type. **37. Cymatosyrinx lunata** [Fla G S, B 3].

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H. simplex (Conrad) (**210**—28, 29). Surface smooth except for curving growth lines. **Mioc.** (St. Marys): Md., Va.

CRASSISPIRA Swainson 1840

(**Pleurotoma bottae* Valenciennes). Large, asymmetrically biconic "*Drillia*," rather elegantly sculptured both axially and spirally. **Tert.** (Atlantic Coast and Caribbean area) — **Recent** (Atlantic and Pacific Coasts).

C. calligona (Maury) (**210**—30) **M. Mioc.:** Fla. (Chipola).

COCHLESPIRA Conrad 1865

(= ANCISTROSYRINX Dall 1881; COCHLESPIROPSIS Casey 1904)

(**Pleurotoma cristata*). Sides of whorls often vertical and subparallel, with strong tendency to become bicarinate at times, and to grow large beads or spines, and then again to suppress such ornamentation. **Eoc.–Recent.**

***C. cristata** (Conrad) (**210**—31). Small, slender fusiform turrids with crenate periphery. **Olig.:** Miss.

DRILLIA Gray 1838

(**D. umbilicata*). "Form genus," applied to small turrids with stout shells; aperture wide; anal sinus wide and deep, stromboid notch deep, siphonal notch very deep, siphonal fasciole strongly inflated, producing an umbilicus between it and detached inner lip; sculpture consists of swollen axial ribs terminating at anal fasciole, and of closely spaced fine spirals. This genus is included for comparison, but no species are listed.

DRILLUTA Wade 1916

(**D. communis*). Differs from "*Drillia*" in lacking posterior siphonal notch and having columellar plaits; differs from typical *Voluta* in having higher spire and fewer transverse folds. **U. Cret.** (Tenn., Tex.).

***D. communis** Wade (**210**—35, 36). **Ripley:** Tenn.

CYMATOSYRINX Dall 1898

(**Pleurotoma lunata* Lea). Like "*Drillia*," but lacking spiral sculpture; aperture wide; siphonal notch deep, narrow; siphonal fasciole swollen and limited; deep, narrow stromboid notch which leaves its trace across body whorl; anal sinus narrow. **Tert.**

***C. lunata** (Lea) (**210**—37). **U. Mioc.:** Va., Carolinas, Fla; **Plioc.:** Carolinas, Fla. (Caloosahatchee).

CORONIA Gregorio 1890

(**Pleurotoma acutirostra* Conrad = *Pleurotoma childreni* Lea). Turrids characterized by large, conic, multispiral protoconch in which earlier whorls are smooth, later costate; and by slender fusoid conch; commonly called *Gemmula*. **Tert.**

C. childreni (Lea) (**210**—26, 27). **Eoc.:** Ala. (Gosport).

SCOBINELLA Conrad 1847

(**S. coelata*). Turrids with ornamentation consisting of a series of knobs made by deep growth lines crossed by deep spirals; a narrow depressed sinus band, generally with a median row of beading; a remarkable inconstancy as regards columellar folding and liration within outer lip. **Early Tert.** (Gulf Province; Pacific Coast).

S. claytonensis (Gabb) (**210**—33, 34). **Eoc.:** Cal.

***S. coelata** Conrad (**210**—32). **Olig.** (Vicksburg): Gulf Coast.

CONUS Linnaeus 1758

(**C. marmoreus*). "Form genus," with many subgenera; whorls with narrow shoulder and straight sides, angle between the two being more or less pronounced; whorls embrace to shoulder angle, thus making a continuously sloping spire, which generally is steepest in young, and may be perpendicular to axis; forward tapering of shell is regular, producing conical form; aperture long, narrow, with anterior and posterior canaliculation; outer lip sharp. **Cret.–Recent** (worldwide).

C. (Lithoconus) sauridens Conrad (**211**—1, 2). **Eoc., Olig.:** Ala. (Claiborne), Miss. (Vicksburg), La. (Jackson).

C. planiceps Heilprin (**211**—3, 4). Spire low, conical, with papillose apex; shoulder surfaces gently concave with strong revolving spiral near suture. **Olig.:** Gulf States (Vicksburg).

C. waltonensis Aldrich (**211**—6, 7). **M. Mioc.:** Fla. (Shoal River).

PLATE 211

[Figures are x1 unless otherwise indicated.]

1–8. Conus spp. 1, 2. C. (Lithoconus) sauridens [B Am Pal 7 (32)]. Top view (x2); apertural view (x2.5). **3, 4. C. planiceps** [Wag Free Inst Sc, Tr 3]. Summit and apertural views of a young shell (x2.5). **5. C. californicus** [San Diego Soc N H, M 1]. **6, 7. C. waltonensis** [USGS, PP 142]. Apertural views of topotypes (x2). **8. C. adversarius** [Fla G S, B 3]. **9. Orthosurcula francescae** (x3) [U Tex B 3301]. **10–12. Clathrodrillia spp. 10. C. ebenina** (x2.5) [Wag Free Inst Sc, Tr 3 (1)]. **11. C. limatula** (x2) [Md G S, Mioc]. **12. C. incilifera** (x2.6) [Md G S, Mioc]. **13–15. Surculites sinuatus** [Cal Ac Sc, Pr (4) 5]. Apertural view of a shell; back views (x1, x2) of two other shells. **16–19. Mangelia spp. 16. M. harveyensis** (x15) [Fla G S, B 3]. **17. M. parva** (x3.6) [Md G S, Mioc]. **18, 19. M. (Mangelia) hexagona** [USNM, Pr 66, shell (x3); Cal Ac Sc, M 3]. **20–24. Cancellaria spp. 20. C. alternata** (x1.2) [Md G S, Mioc]. **21. C. lunata** (x1.4) [Md G S, Mioc]. **22. C. conradiana** [Wag Free Inst Sc, Tr 3 (1)]. **23. C. gracilioides** (x2) [Md G S, Eoc]. **24. C. crawfordiana** (x1.5) [USNM, Pr 14]. **25. Acteon ovoides** [Md G S, Mioc]. **26, 27. Acteon attenuatus** [USGS Ter 9]. Type and portion of surface enlarged. **28. Orthosurcula persa** [B Am Pal 1 (4)]. **29–32. Acteon spp. 29. A. vaughani** (x8) [Fla G S, B 3]. **30, 31. A. linteus** (x4) [USGS, PP 137]. **32. A. (Acteon) traski** (x3) [Cal Ac Sc, M 3]. **33, 34. Mataxa elegans** [USGS, PP 137]. Type (x2). **35. Trigonostoma tenera** (x3) [Fla G S, B 3]. **36. Aphera waltonensis** (x4) [USGS, PP 142].

C. adversarius Conrad (**211**—8). **U. Mioc.:** Va., S. C., Fla.; **Plioc.:** S. C., Fla.

C. californicus Hinds (**211**—5). Shell pyriform, with rounded or bluntly angulated shoulder and moderately elevated spire; sculpture consisting of fine spiral threads. **Plioc.:** Cal.; **Pleist., Recent:** Cal.; L. Cal., Mex.

CLATHRODRILLIA Dall 1918

(**Pleurotoma gibbosa* Reeve = *Murex gibbosus* Born). Like *Pleurotoma* in general form, but with short canal; apertural notch gentle. **Tert.–Recent.**

C. abundans (Conrad). Canal about half as long as spire, nearly straight; whorls depressed convex, with subsutural concavity and crenulated spiral; ribs acute, nearly straight. **Olig.:** Miss (Vicksburg).

C. incilifera (Conrad) (**211**—12). Shoulder concave, with three strong spirals, lower covered except in body whorl, upper two noded by incomplete ribs; in var. **angulata** Martin, angle is marked by coarse, round, regular nodes which appear just above suture, and apical angle is greater; in var. **distans** Conrad, apical angle is smaller, spire higher, and nodes elongated downward; shell is also less abruptly contracted at base. **Mioc.** (Chesapeake): Atlantic Coast.

C. ostrearum (Stearns). Fusiform, high spired, with narrow concave shoulder bounded by subsutural spiral; ribs numerous, closely set, cancellated by spirals; length 16 mm. **Plioc.–Recent:** Fla. (Caloosahatchee); **Recent:** N. C. to Yucatan.

C. ebenina (Dall) (**211**—10). **Plioc.:** Fla. (Caloosahatchee); **Recent:** Gulf of Mexico.

C. limatula (Conrad) (**211**—11). With concave shoulder and strong, nodulose ribs; no spirals; var. **disimilis** Conrad has ribs obsolete on later whorls, sometimes wholly wanting; in var. **pyramidalis** Martin, ribs are strong but apical angle is much greater than in typical form. **Mioc.** (Chesapeake): Atlantic Coast.

ORTHOSURCULA Casey 1904

(**Pleurotoma longiforma* Aldrich). Large, moderately stout, completely devoid of ribbing and with beak elongate, tapering, relatively slender and straight; spirals closely set, moderate or small in size, sometimes granulose; whorls more or less broadly inflated below and feebly concave posteriorly; outer lip projects medially as broad rounded lobe beyond juxtasutural part; sinus large and posterior; protoconch paucispiral; the genus constitutes a group formerly included under *Surcula*, the species of which have a fusoid outline, multispiral protoconch, moderately long anterior canal, and broad, rather deep siphonal notch set squarely upon the shoulder. **L. Tert.**

O. persa (Whitfield) (**211**—28). **Paleoc.:** Ala.

O. francescae Gardner (**211**—9). **Paleoc.:** Tex. (Kincaid).

SURCULITES Conrad 1865

(**S. annosus*). Characterized by angular whorls strongly carinated at periphery, biconical outline, broad but feeble siphonal notch placed well back toward posterior suture, and crowded spirals finely tesselated by growth lines. **Tert.** (Atlantic and Gulf Coastal Plain; Wash., Cal.).

S. sinuatus (Gabb) (**211**—13–15). Like *S. annosus* in form except that area above shoulder rises upward in a smooth concave curve instead of being pinched in below a sutural collar. **Eoc.:** Cal. (Tejon).

MANGELIA Risso 1826

(**M. striolata*). "Form genus," applied to small turrids which differ from *Pleurotoma* in lacking an operculum. **Eoc.–Recent.**

M. parva (Conrad) (**211**—17). Concave portion of shoulder very narrow, near suture; ribs extending beyond lower suture; spirals fine, numerous. **Mioc.:** Md. (Chesapeake).

M. harveyensis Mansfield (**211**—16). **U. Mioc.:** N. and S. C., Fla.; **Plioc.:** Fla. (Caloosahatchee).

M. (Mangelia) hexagona Gabb (**211**—18, 19). **U. Plioc.:** Cal.; **Pleist.:** Cal.; L. Cal., Mex.; **Recent:** Monterey to San Diego, Cal.; Panama.

CANCELLARIA Lamarck 1799

(**Voluta reticulata* Linnaeus). Moderately spired shells, with generally round whorls; body whorl inflated; broad aperture with short canal or notch; columella with several strong oblique plicae; ribs commonly cancellated by spirals; many subgenera. **Cret.?, Tert., Recent.**

C. gracilioides Aldrich (**211**—23). Suture deeply impressed, with slight subsutral flattening; spirals numerous, finely nodulated; no ribs; outer lip expanded and toothed; columella with three folds. **Eoc.:** Atlantic and Gulf Coasts.

C. conradiana Dall (**211**—22). Whorls somewhat flattened on side, with rather pronounced subsutural flattening; ribs strong, distant; spirals of almost equal strength, numerous; columella with three sharp plaits. **Plioc.** (Caloosahatchee): Fla.

C. alternata Conrad (**211**—20). Round whorled, subglobose; with strong round ribs, thicker in middle, crossed by sharp spirals; aperture broad; outer lip lirate; columella with two strong folds. **Mioc.** (Chesapeake): Atlantic Coast.

C. lunata Conrad (**211**—21). Higher spired than preceding though low coiling; ribs farther apart; aperture drawn out into a somewhat longer canal. **Mioc.** (Chesapeake): Atlantic Coast.

C. crawfordiana Dall (**211**—24). **Mioc.:** Ore. (Empire); **Plioc.:** Cal. (Purisima); **Pleist.:** Cal. (San Pedro); **Recent:** California coast.

TRIGONOSTOMA Blainville 1827

(**Delphinula trigonostoma* Lamarck). Like *Cancellaria*, but with triangular aperture. **Tert.–Recent.**

T. tenera Philippi (**211**—35). **U. Mioc.:** S. C., Fla.; **Plioc.:** N. C. (Waccamaw), Fla. (Caloosahatchee); **Recent:** Gulf of Mexico.

APHERA H. Adams and A. Adams 1854

(**Cancellaria tessellata* Sowerby). Like *Cancellaria;* shell ovate, nonumbilicate; outer lip thickened, inner callous and spread over body whorl. **Tert.–Recent.**

A. waltonensis (Aldrich) (**211**—36). **M. Mioc.:** Fla. (Shoal River).

MATAXA Wade 1916

(**M. elegans*). Differs from *Cancellaria* in having well developed canal, lacking sharp and cancellate sculpture, and having less acuminate spire. **U. Cret.** (Tenn., Tex.).

***M. elegans** Wade (**211**—33, 34). **Ripley:** Tenn.

Superorder Opisthobranchia

Order Tectibranchiata

ACTEON Montfort 1810

(**Voluta tornatilis* Gmelin). Shell with sinistral protoconch differing from *Tornatellaea* chiefly in oaving deeper sutures and consequently more pronounced whorls of spire and only one plication on columella. **Cret.–Recent** (worldwide in warm temperate waters).

A. linteus (Conrad) (**211**—30, 31). **U. Cret.** (Ripley): Md. (Monmouth), Tenn., Miss.

A. attenuatus (Meek and Hayden) (**211**—26, 27) **U. Cret.** (Pierre): Sask. (Bearpaw), Alta; Mont., N. Mex.

A. vaughani Mansfield (**211**—29). **U. Mioc.:** S. C., Fla. (Choctawhatchee).

A. ovoides Conrad (**211**—25). **Mioc.** (Chesapeake): Md.

A. (Acteon) traski Stearns (**211**—32). **Pleist.:** Cal.; L. Cal., Mex.; **Recent:** Cal. to Panama.

AVELLANA Orbigny 1842

(**A. avellana* Brongniart). Generic characters illustrated by following species. **Cret.**

A. bullata (Morton) (**212**—1, 2). Shell about 25 mm long, very globose, diameter nearly as great as height; spire low and rounded, the base only slightly more pointed; surface with fine spiral lines (about 30) crossed by low growth lines. **U. Cret.** (Matawan): N. J., Del., Md., La.

RINGICULA Deshayes 1838

(**R. buccinea* Brocchi). Thick-shelled, with mamillose protoconch, short spire, large body whorl, and outer lip with reflected and greatly thickened margin; columella with callus and two to four plicae. **Cret.–Recent.**

R. pulchella Shumard (**212**—3, 4). Body whorl large with about 16 revolving ridges; outer lip thickened, extended over spire, plicate within; inner lip calloused, with anteriorly placed folds. **U. Cret.:** Tenn. (Ripley), Miss. (Ripley), Tex. (Navarro).

R. dalli Clark (**212**—5, 6). Minute, five-whorled; suture moderately impressed; surface with regular, closely set spirals; outer lip thick, ornamented within; columella with thick callus and two plicae. **Eoc.** (Pamunkey): Md., Va.

OLIGOPTYCHA Meek 1876

(**Acteon concinnus* Hall and Meek = *Cinulia* (*Oligoptycha*) *concinna* (Hall and Meek)). Differs from *Avellana* in having a single prominent fold at base of columella. **U. Cret.** (widespread in N. America).

O. americana (Wade) (**212**—7, 8). **U. Cret.:** Tenn. (Ripley).

O. obliqua (Gabb) (**212**—9). Globular; spire almost covered; body whorl large; lips strongly thickened, inner with one large columellar fold and slight intumescence; surface with spirals; interspiral space with crossbars. **U. Cret.:** Pacific Coast (Chico).

RICTAXIS Dall 1871

(**Tornatella punctocoelata* Carpenter). Like *Acteon,* but with columella projecting anteriorly or truncate obliquely. **Pleist., Recent.**

***R. punctocoelatus** (Carpenter) (**212**—12, 13). **Pleist.:** Cal.; L. Cal., Mex.; **Recent:** Cal. to L. Cal., Mex.

TORNATELLAEA Conrad 1860

(**T. bella*). Shells with short, thick spire of rounded whorls, embracing halfway or more; aperture with anterior and posterior notch; columella with two plications near front and outer lip thick and crenulated near margin; surface strongly spiraled. **Jura.–Mioc.** (Atlantic and Gulf Coasts).

T. cretacea Wade (**212**—10, 11). Characterized by elevated and subcylindrical outline of whorls. **U. Cret.:** Tenn. (Ripley).

T. pinguis Gabb. **Paleoc.:** Cal.

***T. bella** Conrad (**212**—15). Interspiral depressions punctate. **Paleoc., Eoc.:** Md., Va. (Pamunkey), Gulf region (Midway, Wilcox).

ACTEOCINA Gray 1847

(**A. wetherelli* Lea). Shell small, cylindrical, spire low, suture channeled; aperture long, narrow, dilated, and rounded at anterior end; columella bearing oblique basal fold which emerges from aperture and merges into basal lip; sculpture absent or consisting of faint spiral grooves. **U. Olig.–Recent.**

A. canaliculata (Say) (**212**—14). **U. Mioc.:** N. C., Fla. (Choctawhatchee); **Recent** (Atlantic Coast).

A. culcitella Gould (**212**—16–18). Spire low, conical, of about three whorls; suture deep, appearing channeled; outer lip simple; columellar fold prominent. **Plioc.:** Cal.; **Pleist.:** Widespread in Cal. and L. Cal., Mex.; **Recent:** Alaska to L. Cal., Mex.

CYLICHNA Lovén 1846

(**Bulla cylindracea* Pennant). Spire deeply sunken, leaving apical perforation; columella with plications, often umbilicated. **Trias.–Recent.**

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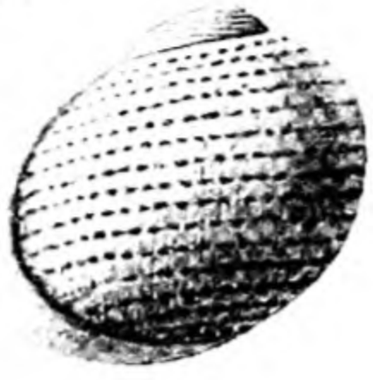

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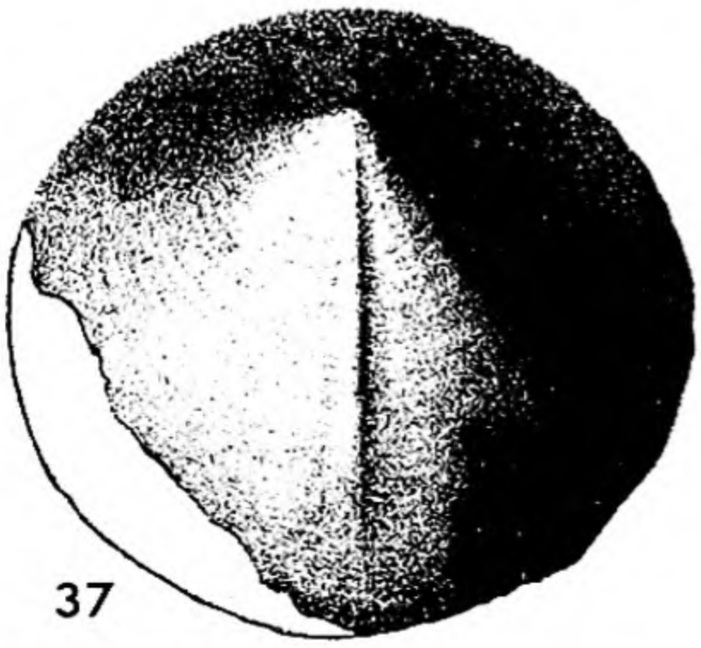

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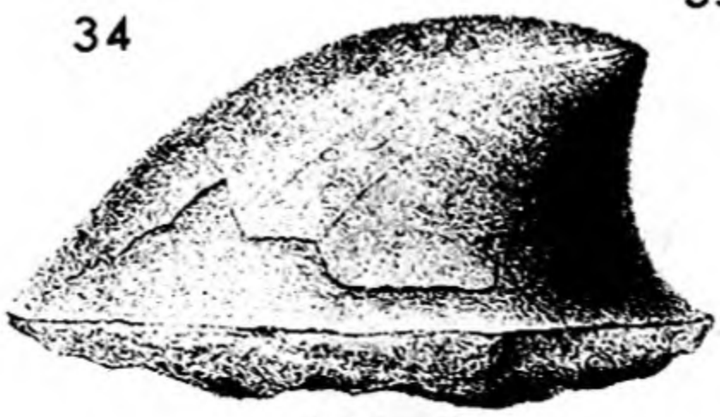

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C. scitula Meek and Hayden (**212**—19, 20). Oval, widest in middle, summit truncated with large depression; aperture narrow; a small indistinct fold near base of inner lip; surface with spirals cancellated by growth lines. **U. Cret.** (Montanan): N. and S. Dak. (Lance), Neb., Colo.

C. secalina Shumard (**212**—25, 26). **U. Cret.:** Tex. (Navarro).

C. alba (Brown) (**212**—21). **Plioc.:** Cal.; **Pleist.:** Cal.; **Recent:** Circumboreal; Arctic Ocean to San Diego, Cal.

BULLA Linnaeus 1758

(= BULLUS Montfort 1810; BULLARIA Rafinesque 1815; *etc.*)

(**Bullus ampulla* Linnaeus). Shell large, ovate or subglobose; spire involute; apical perforation narrow, deep, generally bearing deep spiral grooves; aperture long, wide, anterior, and expanded; columella and parietal wall bearing thick layer of callus; fine spiral grooves at both ends of shell. **Jura.–Recent** (Atlantic and Pacific Coasts of N. America).

B. macrostoma Gabb. Subglobular, with two to three whorls; aperture very broad, broadly rounded in front, narrowly so posteriorly; surface smooth except for growth lines. **U. Cret.** (Ripley): N. J., Ala., Miss.

B. vendryesiana Guppy (**212**—24). **Mioc.:** Jamaica.

MOLOPOPHORUS Gabb 1869

(**Bullia* (*Molopophorus*) *striata*). Generic characters illustrated by genotype. **Olig., Mioc.** (Pacific Coast).

***M. striatus** (Gabb) (**212**—27). Whorls five, convex, first two smooth, others longitudinally ribbed; suture deep, undulated, and bordered by a rib on top of succeeding whorl; aperture broad, outer lip simple, very obscurely notched adjoining suture; inner lip very sinuous; anterior notch deep, narrow and oblique, bordered by two faint, variable folds which revolve obliquely around canal. **Tejon:** Cal.

Order Pteropoda.[1] Pteropods are pelagic mollusks which are naked or covered with a thin shell that is generally transparent, variable in form, and often operculate; shells are accumulating in great numbers on present ocean bottoms, where they form "pteropod ooze." Fossil pteropods are common in Mesozoic and Cenozoic rocks; Paleozoic species referred to this order are now believed to belong to some other division of Mollusca. **Mesozoic–Recent.**

LIMACINA Lamarck 1819

(**Clio helicina* Phipps). Shell thin, spiral, sinistral, with vitreous paucispiral operculum. **Tert.–Recent.**

L. elevata Collins (**213**—22–24). **M. Mioc.:** Vera Cruz, Mex.

CAVOLINA Abildgaard 1791

(**C. natans* = *Monoculus telemus* Linnaeus). Shell thin, vitreous, bilaterally symmetrical, nonoperculate, never coiled; ventricose, slit, and keeled laterally, tricuspid posteriorly; composed of a longitudinally ribbed, planoconvex dorsal piece projecting beyond and over a ventral, strongly arched piece, the two joined in adult shell by internal interlocking processes; aperture constricted and continuous with lateral slits, lips recurved or thickened. **Mioc.** (N. America; Germany, Austria, Hungary, Italy, and Southern Europe); **Plioc.** and **Pleist.** (N. America; Southern Europe).

C. ventricosa (Guppy) (**213**—25–27). **Mioc.:** Jamaica; Haiti.

CLIO Linnaeus 1767

(= CLEODORA Péron and Lesueur 1810)

(**C. borealis* Bruguière). Shell long, pointed, straight or curved, no dorsal groove (as in *Styliolina*, which formerly was included in the pteropods); juvenile shell retains a very small inflation at or just above tip. **U. Cret.–Recent** (Va., Ala., Miss., Tex.; Jamaica; Haiti; Mex.; Europe).

C. (Creseis) hastata (Meyer) (**213**—32–34). **Eoc., Olig.:** Ala., Miss.

VAGINELLA Daudin 1800

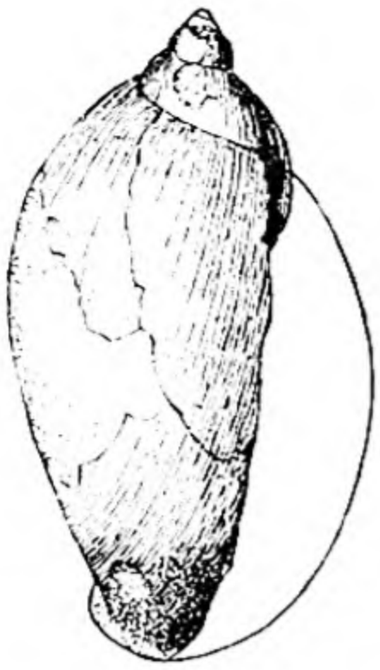
(**V. depressa*). Shell flattened, flask-shaped or slightly curved, lateral margins near apex developed into small keels, ventral side sometimes transversely wrinkled; aperture constricted, elongate-oval, simple or with strongly reflected lip; apex blunt, closed by a septum. **U. Cret.** (Syria); **Olig.** (Australia); **Mioc.** (N. and S. America; Austria; Hungary; Italy).

[1] **Collins, R. L.,** A monograph of the American Tertiary pteropod mollusks: *Johns Hopkins Univ., Stud Geol* 11: 137–324, il, 1934.

PLATE 212

[Figures are x1 unless otherwise indicated.]

1, 2. Avellana bullata [Pal N J 2]. Views of two specimens. **3–6. Ringicula** spp. **3, 4. R. pulchella** (x4) [USGS, PP 137]. **5, 6. R. dalli** (x15) [Md G S, Eoc; after Clark and after Aldrich]. **7–9. Oligoptycha** spp. **7, 8. O. americana** [USGS, PP 137]. Type (x8). **9. O. obliqua** (x3) [Ac N Sc Phila, Pr 78]. **10, 11. Tornatellaea cretacea** [USGS, PP 137]. Type (x4). **12, 13. Rictaxis punctocoelatus** [Stanford U Pub g s 2 (1)]. **14. Acteocina canaliculata** (x8) [Fla G S, B 3]. **15. Tornatellaea bella** [Md G S, Eoc]. **16–18. Acteocina culcitella** [Stanford U Pub g s 2 (1)]. **19, 20. Cylichna scitula** (x3) [USGS Ter 9]. Two views of type specimen. **21. Cylichna alba** (x2) [Stanford U Pub g s 2 (1)]. **22, 23. Pleurolimnaea tenuicostata** [USGS Ter 9]. Two views of type (x2, x1). **24. Bulla vendryesiana** [Carnegie Inst, Pub 385]. Holotype (x1.5). **25, 26. Cylichna secalina** [U Tex Pub 4101; print furnished by L. W. Stephenson]. Views of neotype (x4). **27. Molophorus striatus** [Pal Cal 1]. **28–39. Anisomyon** spp. [28–31, 33–39: USGS Ter 9]. **28–31. A. patelliformis.** Top view of a specimen; top view of type; side and anterior views of another specimen. **32. A. haydeni** [U Tex Pub 4101; print furnished by L. W. Stephenson]. Neotype. **33, 34. A. subovatus.** Side and top views of type. **35, 36. A. sexsulcatus.** Side and top views of type. **37–39. A. borealis.** Top, side, and anterior views.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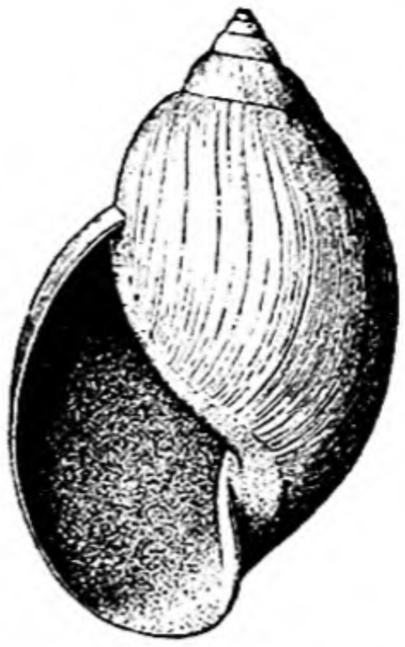
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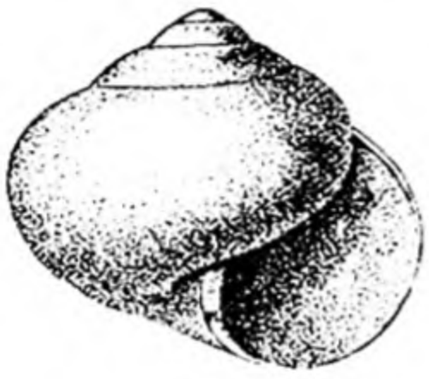
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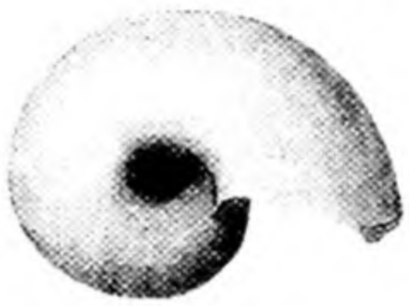
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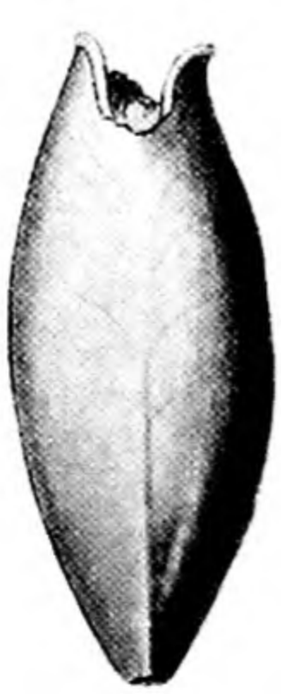
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V. chipolana Dall (**213**—28–31). **Mioc.:** Fla. (Chipola).

Superorder Pulmonata

ANISOMYON Meek and Hayden 1860

(**Helcion patelliformis*). Shell patelliform with oval or circular (rarely ovoid) aperture, central or between center and anterior end; beak pointed, more or less strongly recurved but not spiral, generally broken away; muscle scar horseshoe-shaped, open in front, in form of strong band on left and weak or broken line on right (**212**—28–39); surface smooth, sometimes with a few coarse plications, more rarely finely striate. **Jura., Cret.** (Gulf of Mexico and western N. America).

***A. patelliformis** Meek and Hayden (**212**—28–31). Subovate, broadest posteriorly, high, with beak rather sharp, slopes irregularly convex. **U. Cret.** (Pierre): S. Dak., Neb., Mont., N. Mex.

A. meekii Gabb. Elliptical, apex nearly central, strongly pointed and curved; surface flat, with faint, concentric undulations. **L. Cret.:** Vancouver Island (Nanaimo); Cal. (Horsetown).

A. haydeni Shumard (**212**—32). Beaks point posteriorly. **U. Cret.** (Navarro): Ark., Tex.

A. borealis (Morton) (**212**—37–39). Very large; beak eccentric, sometimes almost anterior; a regular rounded fold from beak to posterior end. **U. Cret.** (Pierre): S. Dak., Colo., N. Mex.

A. centralis Meek. Broader than *A. meekii*, more nearly circular; slopes, except anterior one, nearly straight; surface with fine radiating striae and a few coarse, radiating grooves. **U. Cret.:** Coloradoan of Colo. and N. Mex.; also western Canada.

A. subovatus Meek and Hayden (**212**—33, 34). **U. Cret.** (Pierre): S. Dak., Mont.

A. sexsulcatus (Meek and Hayden) (**212**—35, 36). Beak in anterior third; surface with six radiating grooves. **U. Cret.** (Pierre): Mont., Colo.

PLEUROLIMNAEA Conrad 1866

(**Limnaea tenuicostata* Meek and Hayden). Characterized by its small size, slender form, and regularly costate surface. **Cret.–L. Eoc.**

***P. tenuicostata** (Meek and Hayden) (**212**—22, 23). Very slender, anterior end of lip extended; surface with sharp, narrow, flexuous costae. **Eoc.:** N. Dak. (Fort Union), Utah; Alta. (Paskapoo).

PHYSA Draparnaud 1801

(**Bulla fontinalis* Linnaeus). Shell thin, reversed (sinistral); aperture large; columella twisted or simple; surface smooth; fresh-water; some American investigators prefer PHYSELLA Haldeman 1843 (**Physa globosa*) for American forms. **Jura.–Recent.**

P. copei White (**213**—1, 2). Large, elongate; spire small; body whorl relatively slender. **U. Cret.:** Sask., Alta.; Mont. (Judith River).

P. pleromatis White (**213**—3). **U. Cret.:** Alta.; **Eoc.** (Wasatch): Wyo., Colo., Utah.

P. meigsii Dall (**213**—4). Spire higher and of more whorls than *P. copei;* lip much prolonged anteriorly. **Plioc.:** Fla. (Caloosahatchee).

PLANORBIS Mueller 1774

(**Helix cornea* Linnaeus [controversial]). "Form genus"; coiled, typically in discoid manner, the entire spire below body whorl, but not symmetrically involute; aperture oval, varying to crescent-shaped and with sharp outer margin; fresh-water. **L. Jura–Recent.**

Conchologists doubt that *Planorbis* exists in the living American fauna, hence it should probably be excluded from the fossil faunas also, as suggested by Henderson (1935, 243). In spite of this uncertainty, it seems best to leave the species under *Planorbis* pending further investigation.

P. veternus Meek and Hayden (**213**—20, 21). Small; whorls numerous, regularly enlarging, coiled nearly in single plane. **Jura.** (Morrison): S. Dak., Wyo., Colo.; B. C.

P. amplexus Meek and Hayden (**213**—14, 15). Numerous whorls, very gradually enlarging; deep umbilicus, with shell slightly angulated around it. **U. Cret.** (Pierre): Mont.

P. planoconvexus Meek and Hayden (**213**—5, 6). Spire flat, whorls depressed above, angulated externally and around umbilicus, which is very large. **Eoc.:** N. Dak. (Fort Union).

P. spectabilis utahensis Meek (**213**—11–13). Large and much compressed vertically; aperture transverse; outer margin subangular; var. **spectabilis** has outer margin more rounded. **Eoc.:** Wyo. (Bridger), Utah.

P. leidyi Meek and Hayden (**213**—16, 17). Stout and thick with much embracing whorls, small umbilicus, and flat spire. **Olig.:** S. Dak. (White River).

P. conanti Dall (**213**—7, 8). Spire sunken; whorls embracing to moderate extent, upper surface with angulation below suture; height and width of aperture nearly equal. **Plioc.:** Fla. (Caloosahatchee).

PLATE 213

[Figures are x1 and from USGS, An Rp 3 (many of these after Meek in USGS Ter 9) unless otherwise indicated; JHU = Johns Hopkins U, Stud G 11.]

1–4. Physa spp. **1, 2. P. copei. 3. P. pleromatis. 4. P. meigsii** [Wag Free Inst Sc, Tr 3 (1)]. **5, 6. Planorbis planoconvexus.** Peripheral and top views of type. **7, 8. Planorbis conanti** (x1.3) [Wag Free Inst Sc, Tr 3 (1)]. **9, 10. Helix leidyi. 11–17. Planorbis** spp. **11–13. P. spectabilis utahensis.** Apertural, top, and basal views. **14, 15. P. amplexus.** Upper view of type specimen; basal view of same enlarged. **16, 17. P. leidyi.** Apertural and basal views, enlarged several times. **18, 19. Helix vetusta** [USGS Ter 9]. Type. **20, 21. Planorbis veternus** (x5). Cross section and side view. **22–24. Limacina elevata** [JHU]. Apertural, lower, and upper views of type (x27). **25–27. Cavolina vetricosa** [JHU]. Ventral, left lateral, and dorsal views (x8). **28–31. Vaginella chipolana** [JHU]. Ventral and lateral views (x8); same (x6) and after Dall. **32–34. Clio (Creseis) hastata** [JHU]. Type (x8); apex of type (x50); apex of another specimen (x50).

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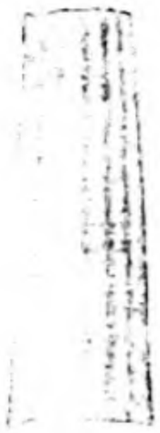
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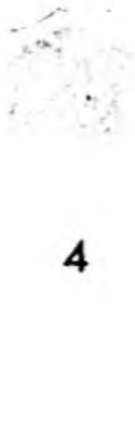
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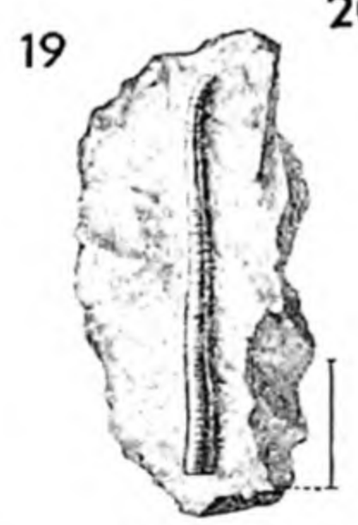
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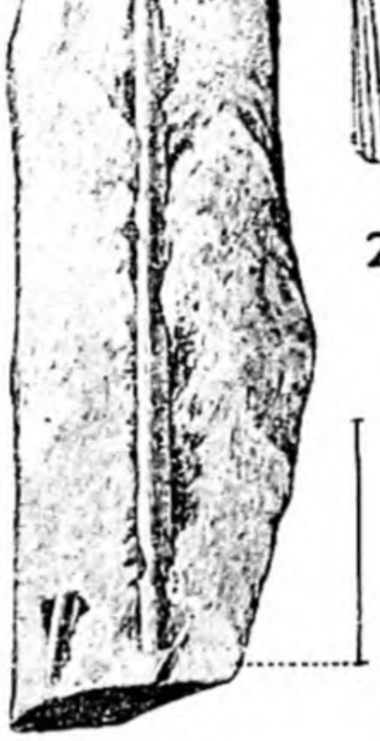
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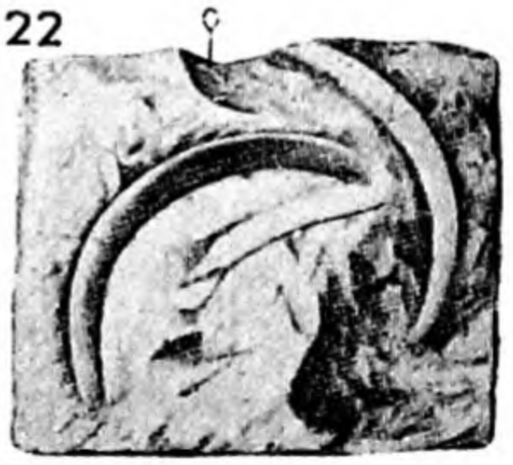
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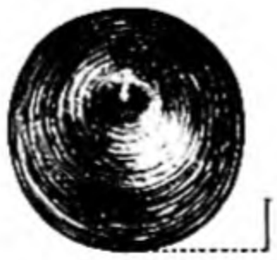
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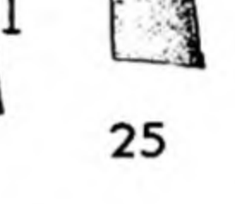
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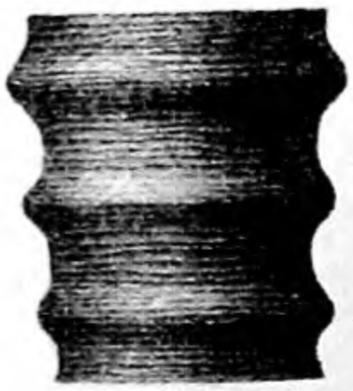
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HELIX Linnaeus 1758

(**H. pomatia*). Generally thin-shelled, of many whorls, more or less regularly increasing, flat- or low-spired (obtuse); aperture incomplete, with disconnected margin; umbilicus present or absent; lip simple or with terminal varix; many subgenera are recognized, and more than 3,400 species have been described; terrestrial. **Eoc.–Recent.**

According to Henderson (1935, 132) many of the species now referred to *Helix* probably belong to other genera, but the unsatisfactory state of knowledge, due largely to lack of soft parts for taxonomic determination, makes it impossible to indicate more than provisional references.

H. vetusta Meek and Hayden (**213**—18, 19). Shell subglobose, height about 10 mm, breadth 10.7 mm; length of aperture 6.25 mm, breadth 5 mm. **U. Cret.:** Mont. (Judith River), Wyo. (Lance).

H. leidyi Hall and Meek (**213**—9, 10). High spired; apical angle approaching 90°; many whorled; body whorl subglobose. **Olig.:** S. Dak. (White River), Colo., Utah.

CLASS SCAPHOPODA[1]

Scaphopods are marine mollusks which have a bilaterally symmetrical body protected by a calcareous shell that is tubular, open at both ends, and generally somewhat curved. The concave side of the shell is dorsal. The larger of the two openings is the mouth, which is anterior. Additions to the shell are made at this end. The smaller end suffers from wear and resorption and in some genera becomes notched or slit. The shell substance consists of three distinct layers.

Modern scaphopods usually live in fairly deep water, where they are partly embedded in mud or sand. Their known depth range is from 2 to more than 2400 fathoms (14,400 feet); fossil species probably lived at moderate depths.

[1] **Pilsbry, H. A., and Sharp, B.,** Scaphopoda, in Tryon's Manual of Conchology 17: 1–311, pl 1–48, 1897–1898; Scaphopoda of the San Domingo Tertiary: *Ac N Sc Phila*, Pr 1897: 465–576, il, 1898. (Also see many other articles by Pilsbry, and by Pilsbry and Sharp.)

Geologically the scaphopods are old. *Dentalium* first appears in the Ordovician, and large species of *Plagioglypta* (a subgenus which became extinct before the close of the Mesozoic) occur in Carboniferous rocks. Not until the Cretaceous, however, are fossil scaphopods at all common.

Pilsbry and Sharp (1898) divide the class into the two families Dentaliidae and Siphonodentaliidae.

DENTALIIDAE. Shell with largest diameter at oral opening; *Dentalium*, with its numerous subgenera, is usually the only genus recognized.

DENTALIUM Linnaeus 1758

(**D. elephantinum*). Shell tusklike, tubular, curved, and regularly tapering, with circular cross-section and open ends; surface bearing strong longitudinal ribs or striae, or smooth; apex entire or with notch or slit. **Ord.–Recent** (distribution worldwide in ancient deposits and modern seas).

The genus usually is divided into numerous subgenera, of which the following are the most important with fossil representation:

DENTALIUM (*ss*) Pilsbry and Sharp 1897. Shell prismatic or decidedly ribbed, the ribs often very strong toward apex where there are generally 4 to 14, but as many as 20; apex lacks notch or slit or has a short one.

GRAPTACME Pilsbry and Sharp 1897. Shell characterized by fine longitudinal striae near apex or rarely throughout; cross-section circular or nearly so.

ANTALIS H. Adams and A. Adams 1854. Shell with circular cross-section, solid, becoming striate toward apex, which is simple, notched, or with supplemental tube.

PLAGIOGLYPTA Pilsbry 1898. No longitudinal sculpture, but sculptured with extremely oblique, crowded, encircling wrinkles; slit normal or wanting. **Carb.–Trias.**

LAEVIDENTALIUM Cossman 1888. Shell large, arcuate, smooth with growth lines only, and circular in cross-section; apex typically simple.

D. (Laevidentalium) martini Whitfield (**214**—16). Shell smooth, rather rapidly expanding, moderately curved; growth lines arching forward on concave side. **Dev.:** Ohio (Columbus).

PLATE 214

[Figures are x1 unless otherwise indicated; lines alongside some of the figures represent natural size.]

1–17. Dentalium spp. 1–4. D. subarcuatum [USGS, M 18]. Two specimens; an enlarged surface and cross section. **5, 6. D. stramineum** [Pal Cal 1]. Side view and cross section. **7. D. (Laevidentalium) pauperculum** [USGS, PP 128]. Type specimen (x2). **8–10. D. gracile** [USGS Ter 9]. Enlargement of surface; cross section of large end; part of shell. **11. D. attenuatum** [Md G S, Mioc]. **12, 13. D. (Graptacme) minutistriatum** [Md G S, Eoc; USGS, PP 126]. **14, 15. D. (Laevidentalium) caduloide** [Md G S, Mioc; after Dall]. Diagrammatic cross section and larger part of shell. **16. D. (Laevidentalium) martini** [Ohio G S 7]. **17. D. thalloide** [Conrad: Fos Shells Tert Fm, 2 ed]. **18. Coleolus gracilis** [NAIF]. **19. Coleolus tenuicinctus** [Pal N Y 5 (2)]. **20, 21. Coleoloides typicalis** [USGS, An Rp 10]. A nearly complete specimen and part of a specimen enlarged (x3). **22, 23. Dentalium (Antalis) cooperi** [Pal Cal 1]. A fragmental specimen and part of same enlarged. **24, 25. Dentalium (Graptacme) mediaviense** [B Am Pal 1]. **26–30. Cadulus spp. 26. C. turgidus** (x3) [B Am Pal 1]. **27, 28. C. obnutus** [USGS, PP 137]. End and side views (x6). **29. C. abruptus** [Md G S, Eoc]. **30. C. thallus** [Md G S, Mioc]. **31. Dentalium (Plagioglypta) canna** [USGS, W 100th Mer 4 (1)]. **32–36. Hyolithellus micans** [USGS, B 30]. Enlargement of terminal portion of nearly complete specimen; exterior of operculum; a crushed specimen in shale; impression of interior and internal surface of operculum. **37. Helenia bella** [USGS, An Rp 10]. A fragment of limestone with two nearly entire shells. **38–40. Orthotheca emmonsi** [USGS, B 30]. Views of two specimens and a cross section. **41–47. Tentaculites spp. 41, 42. T. gyracanthus** [Pal N Y 7 Suppl]. Two specimens enlarged (x6) and a slab showing numerous shells. **43, 44. T. bellulus** [Pal N Y 5 (2)]. A typical specimen and portion of same enlarged. **45, 46. T. scalariformis** [Pal N Y 5 (2)]. Portion much enlarged and a typical specimen. **47. T. attenuatus** [Pal N Y 5 (2)].

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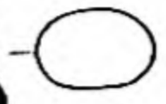

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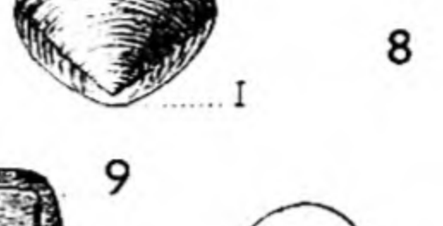
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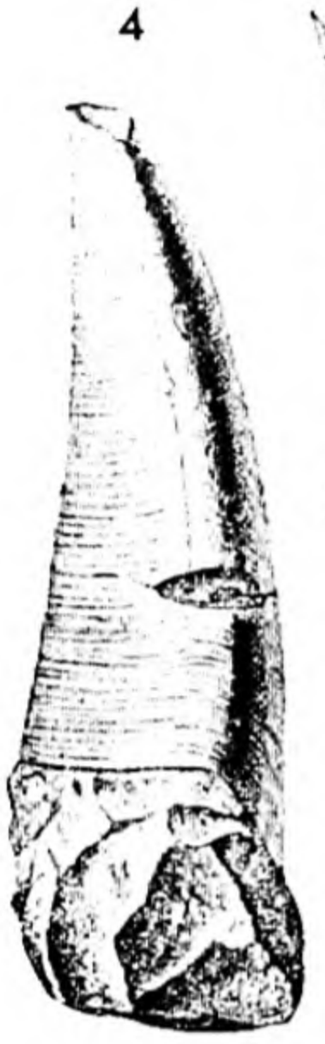
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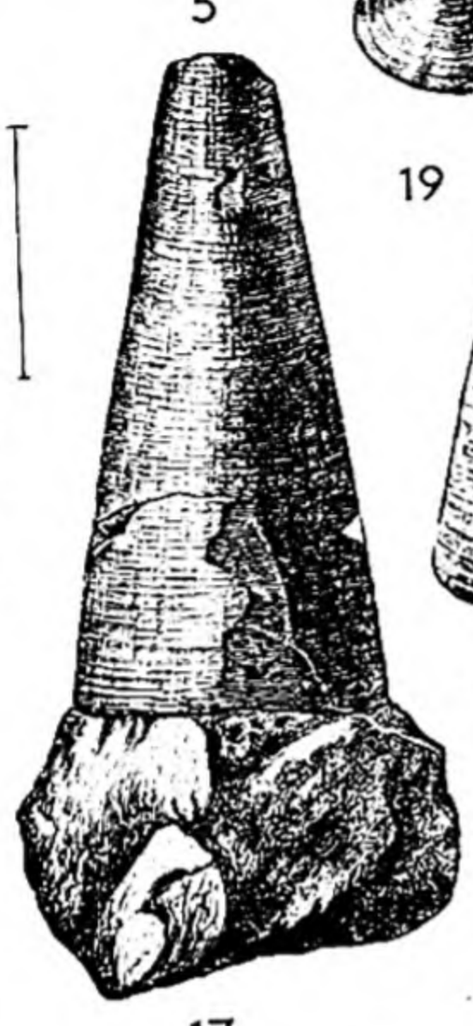
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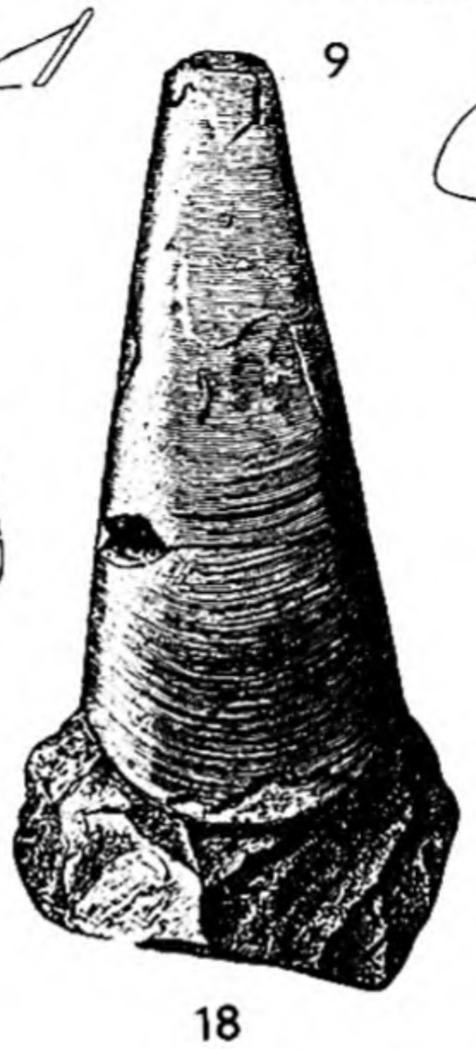
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D. (Plagioglypta) canna White (**214**—31). Shell straight. **Perm.:** Tex. (Delaware Mt.), Wyo. (Florelle), Colo., N. Mex. (Chupadira); Alta. (Rocky Mt. quartzite); Idaho (Phosphoria), Utah, Ariz. (Kaibab).

D. subarcuatum Conrad (**214**—1–4). Slender, very gently arcuate, tapering in 47 mm from 5 to 2 mm; internal fillings smooth or with faint lines, and with rounded ridge on concave side; shell surface with about 12 longitudinal costae and fine annular striae. **U. Cret.** (Ripley): N. J., Ala.

D. (Laevidentalium) pauperculum Meek and Hayden (**214**—7). Minute, smooth, gently curved, gradually tapering; shell thick, growth lines oblique. **U. Cret.:** Md. (Monmouth), N. Dak. (Lance), Western Interior (Pierre, Fox Hills).

D. gracile Hall and Meek (**214**—8–10). Very gently tapering and slightly curved; cross-section nearly or quite circular; apical end smooth; fine round longitudinal lines over most of shell, these increased by intercalation and becoming obsolete toward larger end. **U. Cret.** (Pierre): Mont.; Sask., Alta.

D. stramineum Gabb (**214**—5, 6). Numerous longitudinal lines or ridges. **U. Cret.:** Cal. (Chico).

D. (Antalis) cooperi Gabb (**214**—22, 23). Very gently curved, moderately tapering; surface bearing numerous fine parallel striae separated by depressed lines. **U. Cret:** Chico of Cal. and Sucia Island; **Eoc.** (Martinez–Tejon): Cal.

D. (Graptacme) mediaviense Harris (**214**—24, 25). Rapidly tapering, curved near small end; smooth near large end, elsewhere striated with fine, sharp, alternating longitudinal striae; faint concentric annulations present; shell thick except near larger end; maximum diameter 9 mm. **Paleoc.** (Midway): Ala., Miss.

D. (Graptacme) minutistriatum Gabb (**214**—12, 13). Smaller and less rapidly tapering than preceding; curvature gentle, with minute, regular, nonalternating striae. **Eoc.:** Md. (Nanjemoy), Tex. (Claiborne).

D. thalloide Conrad (**214**—17). Costae strong, alternating or of three sizes. **Eoc.:** Claiborne of Ga., Ala., Miss., La.; Jackson of Ga.

D. attenuatum Say (**214**—11), Surface with 12 to 16 rounded ridges separated by broader interspaces and obsolete toward narrow end. **Mioc.** (Chesapeake): Md. to S. C., Fla. (Alum Bluff).

D. (Laevidentalium) caduloide Dall (**214**—14, 15). Associated with *D. attenuatum*.

SIPHONODENTALIIDAE. Shell generally smooth, often inflated. *Cadulus* is the common genus.

CADULUS Philippi 1844

(**C. ovulum*). Differs from *Dentalium* in being swollen near middle and tapering toward each end. **Cret.–Recent** (widespread throughout Western Hemisphere).

C. obnutus (Conrad) (**214**—27, 28). Shell a small, thin, smooth, slightly arched tube (3 mm long, maximum diameter 1 mm), strongly inflated centrally. **U. Cret.:** N. J. (Woodbury), N. C. (Black Creek), Tenn. (Ripley), Ga. to Ala. (Eutaw, Ripley), Miss. (Ripley).

C. turgidus Meyer (**214**—26). Rapidly increasing for about two-thirds of length, then more rapidly decreasing; cross-section circular. **Paleoc.** (Midway): Ala.

C. abruptus Meyer and Aldrich (**214**—29). **Eoc.:** Md. (Nanjemoy, Aquia), Ala. (Chickasaw).

C. thallus (Conrad) (**214**—30). **Mioc.:** Md. and Va. (Chesapeake), N. C., S. C., Fla. (Alum Bluff).

C. depressicollis Pilsbry and Sharp. Slender, and with decidedly concave area on flattened surface adjacent to lip on convex side. **Olig.:** San Domingo

MOLLUSCA INCERTAE SEDIS

Under this heading are discussed several well-known and widely distributed genera which have many molluscan features but which also vary so much from any living Mollusca that they can not be placed in any recognized class. Consequently, they are grouped here merely for convenience. There is no attempt to consider these widely different groups as divisions of one homogeneous zoological unit; it is altogether probable, on the contrary, that some of the genera discussed below may belong to other phyla (e.g. *Tentaculites*, which may be some sort of worm tube).

HYOLITHES Eichwald 1840

(**H. acutus*). Shell calcareous, straight or curved, and modified conical; cross-section triangular or elliptical; margin of flattened dorsal side projects somewhat above opposite wall, causing thus a forward bending of the engirdling growth lines;

PLATE 215

[Figures are x1 and after Walcott [USGS, B 30 and An Rp 10] unless otherwise indicated; lines alongside some of the figures represent natural size.]

1–52. Hyolithes spp. 1–6. H. americanus. Two opercula, a cross section of a shell, and views of three specimens. **7–9. H. billingsi.** Two views of a specimen and an operculum. **10–13. H. impar.** Operculum; shell with diagrammatic cross section; two views of the type. **14. H. danianus** [USGS, B 10]. **15. H. acadicus** [USGS, B 10]. **16–20. H. princeps.** Three views of a large specimen; operculum; cross section of shell. **21–23. H. similis. 24–26. H. quadricostatus. 27–30. H. terranovicus.** Three views of a specimen and an operculum. **31–33. H. shaleri** [USGS, B 10]. Two views of a specimen and a cross section. **34–41. H. communis.** A well preserved specimen; two cross sections showing irregular thickness of shell; operculum; four views of several specimens. **42–44. H. baconi** [Wis G S 4]. **45, 46. H. primordialis** [Wis G S 1]. **47–49. H. neapolis** [N Y St Mus, M 6 (2)]. Two views of a shell (x7) and a complete specimen (x1.5). **50–52. H. decipiens** [N Y Ac Sc, Tr 14]. Diagrammatic cross section and two views of a specimen. **53. Styliolina fissurella** [Pal N Y 5 (2)]. A large compressed specimen with obscure transverse striae.

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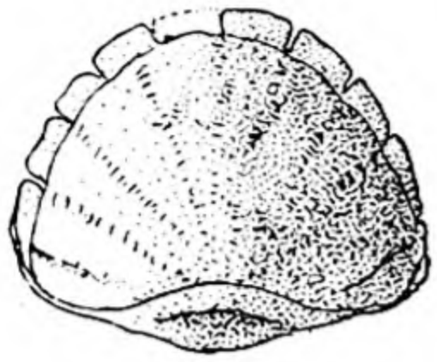

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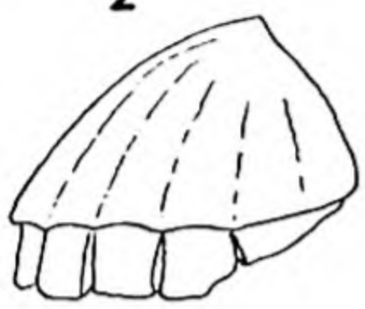

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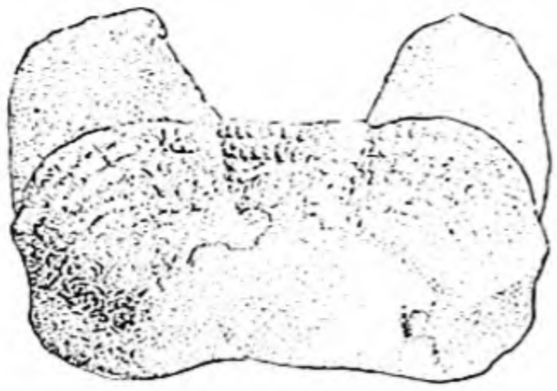

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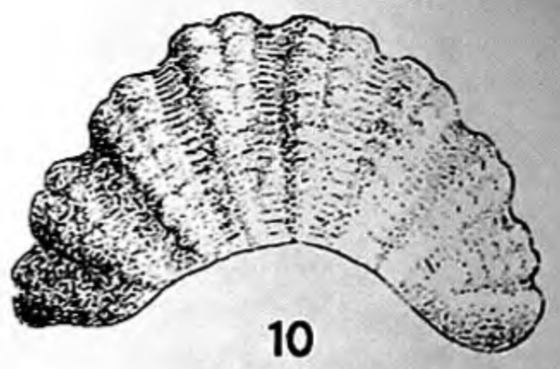

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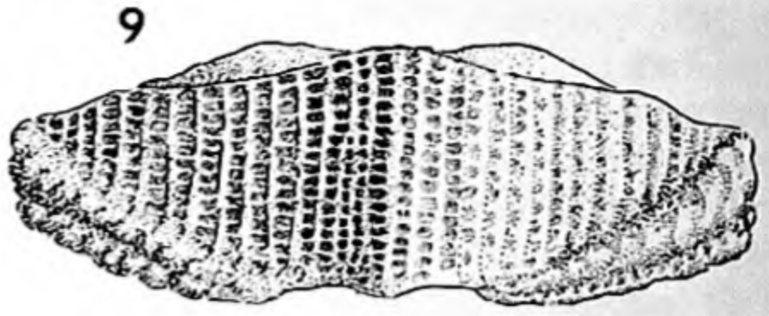

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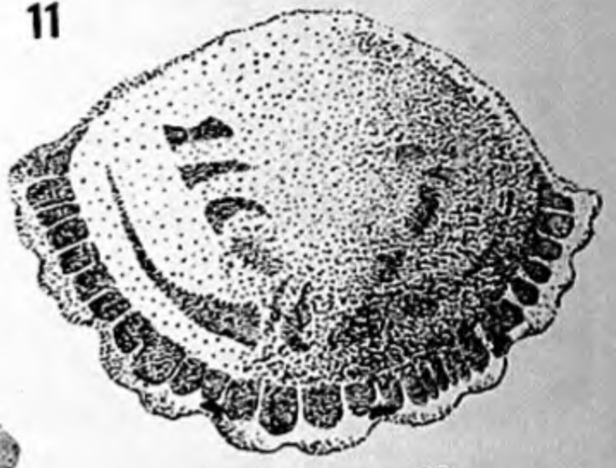

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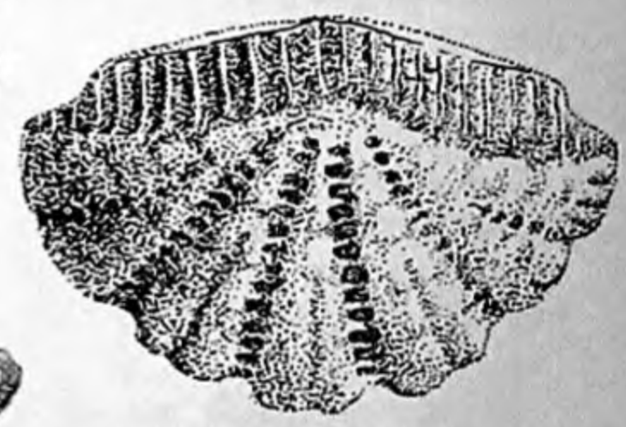

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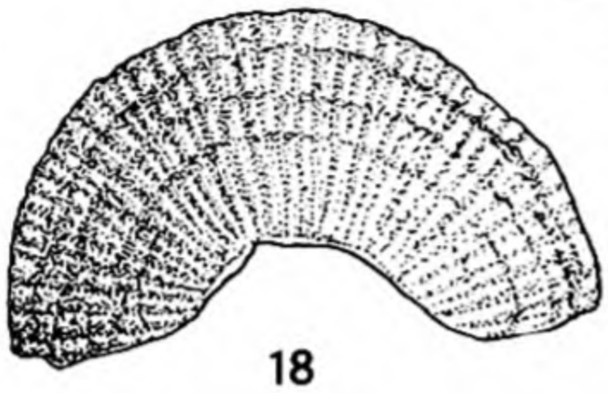

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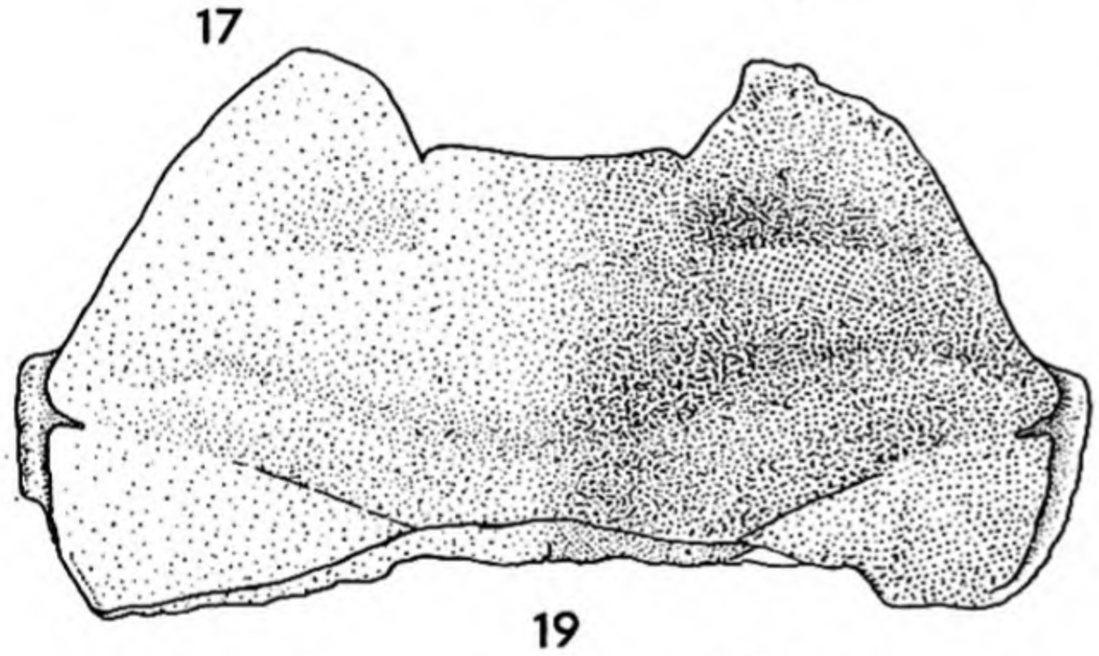

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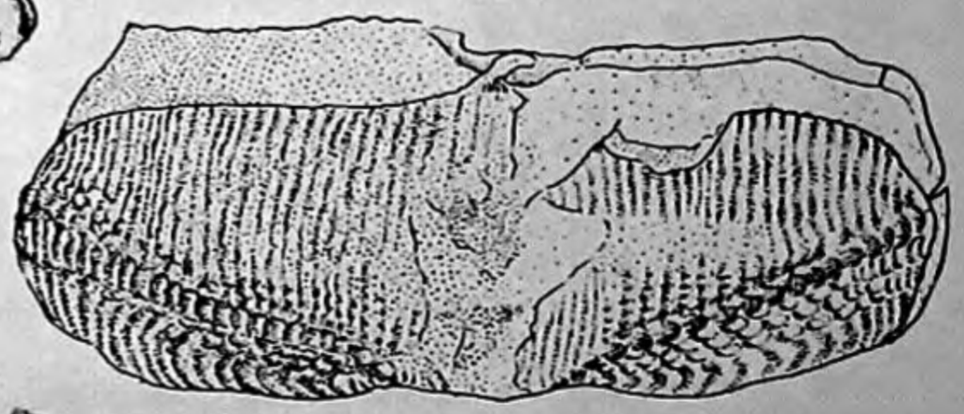

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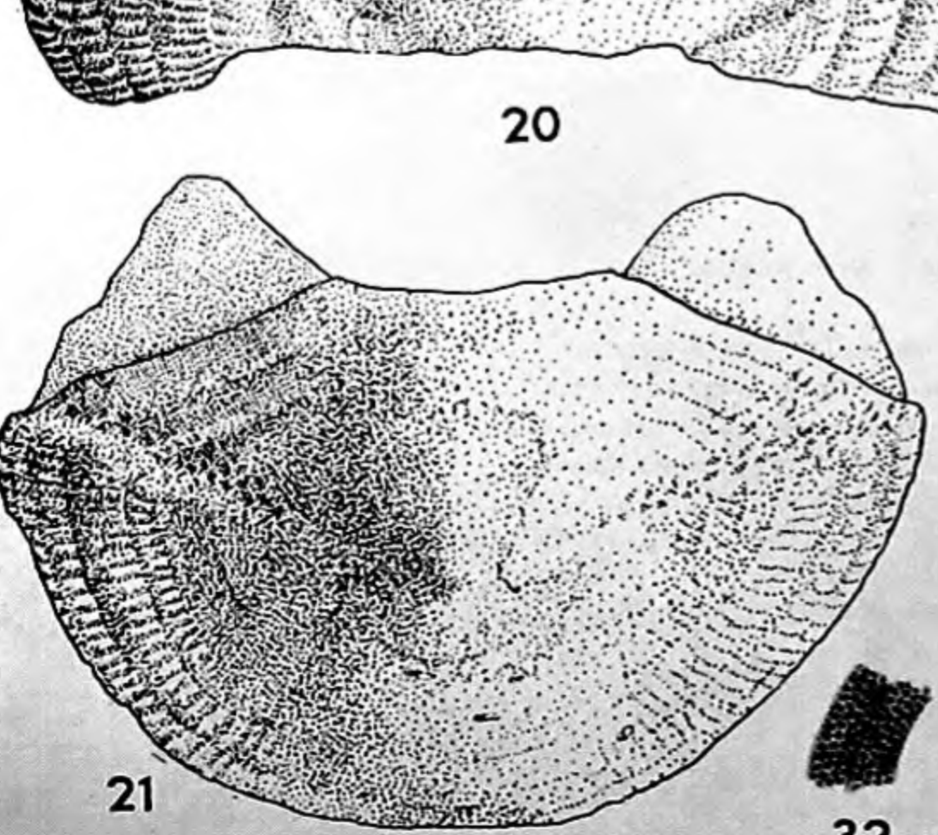

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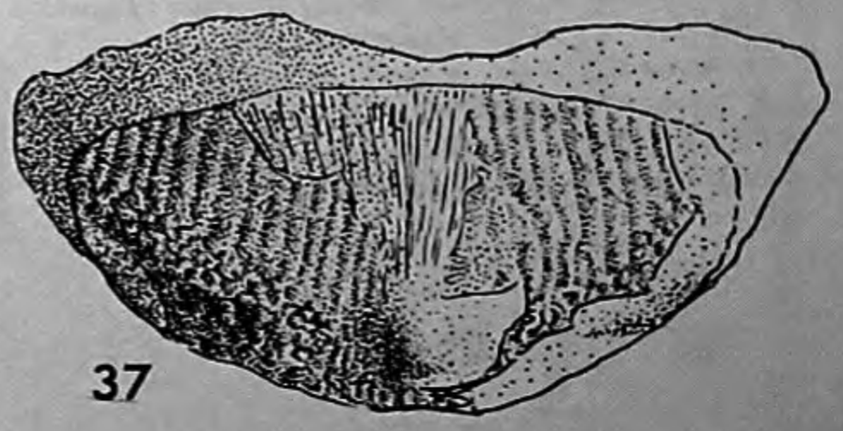

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opening closed by a concentrically striated operculum. **Camb.–Perm.**

H. americanus Billings (**215**—1–6). Growth lines curve forward on dorsal side, pass downward over sides at nearly right angles, and curve slightly backward over the ventral side; shell wall thin. **L. Camb.:** Newf.; Que.; Mass., N. Y.

H. billingsi Walcott (**215**—7–9). Cross-section subtriangular; shell wall thick, composed of successive layers. **L. Camb.:** Labrador; Mass.?, Utah, Nev.

H. impar Ford (**215**—10–13). Usual length, 32 mm; one or more transverse imperforate septa near apex; cross-section generally regularly oval; apical angle about 10°; shell wall thick, consisting of an inner layer irregularly separated from an outer one. **L. Camb.:** Mass., N. Y.

H. princeps Billings (**215**—16–20). Apical angle 13° to 15°; dorsal side flat to slightly convex and produced anteriorly into a rounded lip; ventral face ranging from uniformly convex transversely to asymmetrical. **L. Camb.:** Newf.; Mass.

H. quadricostatus Shaler and Foerste (**215**—24–26). Apical angle about 17°; shell four-sided, the dorsal broad, flat, or slightly concave along median line. **L. Camb.:** Newf.; Mass.

H. similis Walcott (**215**—21–23). Differs from *H. americanus* in having longitudinal striae and a smaller apical angle. **L. Camb.:** Newf.

H. communis Billings (**215**—34–41). Nearly cylindrical except for slight flattening on one side. **L. Camb.:** Newf. to Md.

H. terranovicus Walcott (**215**—27–30). Cross-section subtriangular or semielliptical; dorsal face less convex than ventral; besides growth lines, which cover entire shell, ventral surface is marked by strong, longitudinal raised lines with finer striae between. **L. Camb.:** Newf.

H. decipiens Matthew (**215**—50–52). Apical angle 15°; surface marked only by concentric growth lines. **M. Camb.:** N. B.

H. acadicus Hartt (**215**—15). Surface with concentric growth lines and microscopic longitudinal striae. **M. Camb.:** N. B.

H. danianus Matthew (**215**—14). Cross-section semielliptical; surface with concentric growth undulations. **M. Camb.:** N. B.

H. shaleri Walcott (**215**—31–33). Large shell with dorsal face the least convex transversely and slightly convex longitudinally; growth lines arch forward, forming a strong, rounded anterior lip; surface with fine longitudinal lines; ventral side slightly concave longitudinally, its growth lines nearly transverse. **M. Camb.:** Mass.

H. primordialis Hall (= **"Theca" primordialis** Hall) (**215**—45, 46). **U. Camb.:** Wis. (Cedaria and Crepicephalus zones).

H. baconi Whitfield (**215**—42–44). Dorsal side depressed convex, more abruptly rounded near margins and on edges; surface with transverse striae, which arch gently forward and are parallel to margin of dorsal extension; ventral surface about twice as deep as dorsal, marked by transverse striae directed nearly straight across shell. **M. Ord.** (Platteville): Ind., Wis., Minn.

H. neapolis Clarke (**215**—47–49). Convex side divided into three parts, two flattened marginal areas separated from median convex area by narrow grooves; this condition is accentuated by compression; entire shell surface marked by concentric growth lines only. **Dev.** (Chemung): N. Y.

ORTHOTHECA Novak 1887

(**Hyolithes* (*Orthotheca*) *intermedius*). Differs from *Hyolithes* in abrupt truncation of anterior end; growth lines are thus uniformly engirdling and do not bend forward upon dorsal face. **Camb.**

O. emmonsi (Ford) (**214**—38–40). Shell elongate and slender; apical angle about 8°; dorsal? face flattened or slightly concave; older part of tube septate. **L. Camb.:** Mass., N. Y.

O. cylindrica Grabau. Shell small with circular to subcircular cross-section; apical angle 2° to 5°; older portion of tube septate with septa convex backward. **L. Camb.:** Newf.; Mass.

HELENIA Walcott 1889

(**H. bella*). Shell an elongate, narrow, flattened, curved tube; cross-section and aperture elliptical; surface with transverse, concentric, imbricating growth lines. **Camb.**

***H. bella** Walcott (**214**—37). Curvature nearly semicircular; cross-section an elongated ellipse; apparently open at both ends; possibly referable to the Dentaliidae (Scaphopoda). **L. Camb.:** Newf.

HYOLITHELLUS Billings 1872

(**H. micans*). Differs from *Hyolithes* in the slender elongated from of shell, absence of a flattened face, and especially in star-shaped arrangement of numerous muscle markings on interior of operculum; shell also lacks anterior lip and its accompanying

PLATE 216

[Figures are x1 and from Cal Ac Sc, Pr (4) 11 unless otherwise indicated.]

1–5. Nuttallina californica. Exterior and interior of head valve (x5) and profile of same (x6); exterior of median and tail valves (x5). **6–8. Priscochiton canadensis** [CGS]. **9–14. Callistochiton palmulatus mirabilis.** Left lateral and dorsal views of head valve (x7); exterior view of median valve (x7); right lateral, interior, and dorsal views of tail valve (x9). **15, 16. Chiton (Trachyodon) eocenensis** [Am J Conch 1]. **17–21. Ischnochiton magdalenensis** (x4). Profile and dorsal view of head valve; interior and exterior of median valve; exterior of tail valve. **22–26. Chaetopleura apiculata** [Md G S, Mioc]. Anterior, dorsal, and ventral views of a head valve; exterior and interior views of a tail valve. **27–34. "Chiton" carbonarius** [Ill G S 5]. 27, 30: Dorsal and side views of head valve. 28, 29, 31: Dorsal, ventral, and side views of a median valve. 32: Portion of surface enlarged, showing granular sculpturing. 33, 34: Dorsal and side views of tail valve. **35–37. Mopalia muscosa.** Exterior view of head valve (x3.5); exterior of median valve (x3); exterior of tail valve (x4).

forward bending growth lines on dorsal side. **Camb.**

***H. micans** Billings (**214**—32–36). Shell long, very slender; apical angle 1° to 2°; cross-section circular or broadly ovate. **L. Camb.:** Newf.; Que.; Mass., N. Y., Utah?, Nev.?

COLEOLOIDES Walcott 1889

(**C. typicalis*). Shell elongate, slender, cylindrical; differs from *Hyolithellus* in its spiral longitudinal striae. **Camb.**

***C. typicalis** Walcott (**214**—20, 21). Apical angle exceedingly acute; shell wall apparently very thin; longitudinal striae make one revolution around tube in a length of 16 diameters of shell. **L. Camb.:** Newf.

COLEOLUS Hall 1879

(= COLEOPRION Hall 1876, not Sandberger 1847)

(**Coleoprion tenuicinctum*). Shell very elongate-conical, straight or slightly curved, thick-walled; external surface marked by engirdling striae more or less oblique to shell axis. **Dev.**

C. tenuicinctus (Hall) (**214**—19). Surface with interrupted longitudinal striae. **Hamilton:** N. Y., Md., Ind., Ky. (at Falls of Ohio); **Portage–Chemung:** Md.

C. gracilis Hall (**214**—18). Surface apparently transversely striate. **Hamilton–Chemung:** N. Y.

TENTACULITES Schlotheim 1820

(**T. scalaris*). Shell straight or slightly curved, elongate-conical terminating posteriorly either acutely or in a bulb; cross-section circular; surface with strong transverse rings closely arranged near apex and more distant and stronger near mouth; fine transverse and rarely longitudinal striae present; apical portion often filled with calcareous material or transversely septate. **Ord.–Dev.** (extremely abundant in **Sil.** and **Dev.** strata).

T. gyracanthus (Eaton) (**214**—41, 42). Annulations irregular in strength and distribution, two to four in 1 mm; length rarely over 12 mm. **Sil., Dev.** (Manlius and Keyser): N. Y., Md., W. Va.; New Scotland: N. Y.

T. scalariformis Hall (**214**—45, 46). Differs from *T. bellulus* in the more obtuse annulations of distal portion, with narrower interspaces, and in the more rapidly narrowing apical portion. **Onondaga, Hamilton:** Ont.; N. Y., Va., Ala., Mich.

T. gracilistriatus Hall. Like *Styliolina fissurella* in small size and needlelike form but distinguished by presence of annulations and fine longitudinal striae. **Marcellus–Onondaga:** Ont.; N. Y., Va.

T. bellulus Hall (**214**—43, 44). Annulations acute; interspaces rounded and marked by concentric striae. **Hamilton:** N. Y., Md., Mich., Wis.

T. attenuatus Hall (**214**—47). Slender, with distant, rather irregularly spaced and narrow annulations, the interspaces with concentric striae; length 10 to 12 mm; resembles *T. bellulus* but smaller and with annulations more irregular. **Hamilton:** Ont.; N. Y. to Md.

STYLIOLINA Karpinsky 1884

(Genotype not discovered.) Shells small, needle-shaped, transversely circular; apex solid and usually bulbous; surface smooth except for fine growth lines. **Dev.** (See below for distribution.)

S. fissurella (Hall) (**215**—53). Sharply depressed central fracture line present in all compressed specimens; similar to *Tentaculites gracilistriatus* Hall, from about the same horizon, but not annulated and striated as that form is. **Onondaga–Hamilton:** N. Y. to Md., Mich.; **U. Dev.:** N. Y. to Va., Mich., Ohio, Ind.; Alta.

CLASS AMPHINEURA [1]

The Amphineura are bilaterally symmetrical mollusks which have a dorsal covering of eight plates, or they may lack these altogether. Fossil amphineuran plates are rare but have been reported from numerous formations from **L. Ord.** to **Recent.**

The class is subdivided into the following two orders:

Order Polyplacophora. These are the common chitons — elongate animals which adhere to the substratum by a foot that is coextensive with the body. They bear eight dorsally transverse, calcareo-chitinous plates or valves which occasionally are found fossil. The anteriormost plate is the *head plate;* the posteriormost, the *tail plate;* and the six between, the *median plates.* The shell substance is formed by two distinct layers: (1) an inner, semi-porcelaneous tissue, the *articulamentum;* and (2) an outer surface layer, the *tegmentum.* The former generally projects past the latter to form the mechanism of articulation — the *insertion plates* or *sutural laminae,* which may be divided by *slits* into *teeth.*

Fossil chitons of this order are found along both the Atlantic and Pacific Coasts; living representatives have similar distribution.

PRISCOCHITON Dall 1881

(**Chiton canadensis* Billings). Plates semiconical with an acute apex. **M. Ord.**

***P. canadensis** (Billings) (**216**—6–8). **Black River** (Leray): Pauquette Rapids, Ottawa River, Canada.

CHAETOPLEURA Shuttleworth 1853

(**Chiton peruvianus* Lamarck). Valves with beaded

[1] **Berry, S. S.,** Fossil chitons of western North America: *Cal Ac Sc,* Pr (4) 11: 399–526, pl 1–16, 1922; Fossil chitons from the Pleistocene of San Quintin Bay, Lower California: *AJS* (5) 12: 455–456, 1926. **Dall, W. H.,** On the genera of chitons: *USNM,* Pr 4: 279–291, 1881. **Pilsbry, H. A.,** Monograph of the Polyplacophora. Tryon's Manual of Conchology 14: i-xxxiv; 1–350; pl 1–68, 1892; Idem 15: 5–33, pl. 1–17, 1893; Aplacophora: Idem 17: 281–310, il, 1898.

sculpture; tegmentum strongly developed behind articulamentum; median valves distinctly narrowed at sides; tail valves with short, stubby teeth and posterior mucro. **Tert.–Recent.**

C. apiculata (Say) (**216**—22–26). Valves eight; dorsal triangles with series of elevated points; lateral triangles with scattered elevated points. **Mioc.:** Md. (Calvert), Va.; **Recent:** Atlantic Coast, Cape Cod to Fla.

ISCHNOCHITON Gray 1847

(**Chiton textilis* = *Chiton longicymba* Blainville). Valves and insertion plates thin and smooth, one side-slit in each median valve; scales of girdle flat and striated; sculpture variously developed; sharply cut even teeth throughout. **Tert.–Recent.**

I. magdalenensis (Hinds) (**216**—17–21). **Pleist.–Recent:** Cal.

CALLISTOCHITON Carpenter 1882

(**Chiton pulchellus* Gray). Lateral and terminal areas with radial ribs; insertion plates short and curving out into slits which correspond in position with radial ribs. **Pleist., Recent.**

C. palmulatus mirabilis Pilsbry (**216**—9–14). **Pleist.–Recent:** Cal.

CHITON Linnaeus 1758

(**C. tuberculatus*). The following is a description of subgenus TRACHYODON Dall 1892 (**Chiton eocenensis* Conrad): Insertion plates broad, strong, divided by deep grooves into numerous bifid teeth in head and tail plates; median valves with plates continuous, thin and flat from jugum to girdle, where they have a single slit, on each side of which the plate is strong and toothed; sculpture marked, with lateral areas distinct; tail plate with prominent mucro. (*Chiton ss* of Carpenter has median valves with a single slit in each insertion plate, sinus generally denticulate, and scales closely imbricating.) **Penn.?, Tert.–Recent.**

"C." carbonarius Meek and Worthen (**216**—27–34). **Penn.:** Ill. (?U. Carbondale), Mo. (Labette shale; authority, J. B. Knight).

C. (***Trachyodon**) **eocenensis** (Conrad) (**216**—15, 16). **Eoc.:** Ala. (Claiborne).

NUTTALLINA Carpenter 1879

(**Chiton californicus* Nuttall = *Acanthopleura scabra* Carpenter). Valves narrow, of more or less bizarre form; sculpture of tegmentum strongly granular.

***N. californica** (Nuttall) (**216**—1–5). **Pleist., Recent:** Pacific Coast of N. America.

MOPALIA Gray 1847

(**Chiton hindsii* Sowerby). Valves normally proportioned, broad, transverse, depressed; margin of insertion moderate; tail valve with rounded lobe on posterior part.

M. muscosa (Gould) (**216**—35–37). **Pleist., Recent.:** Pacific Coast of N. America (Alaska to L. Cal.).

Order Aplacophora. Organism wormlike, lacking dorsal plates, and practically without the foot of the preceding order; skin studded with tiny calcareous bodies, but these do not seem to have been reported fossil. **Recent.**

CLASS CEPHALOPODA[1, 2]

The Cephalopoda are the most highly developed of mollusks. Living representatives possess a dis-

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[1] In revising the Cephalopoda we have received valuable assistance from the following: J. Bridge, C. G. Croneis, C. O. Dunbar, R. Flower, W. M. Furnish, R. W. Imlay, A. K. Miller, S. W. Muller, J. B. Reeside, Jr., W. E. Schevill, Gayle Scott, L. W. Stephenson, and P. S. Warren. It is a pleasure to acknowledge this assistance.

[2] **Clarke, J. M.,** Lower Silurian [Ordovician] Cephalopoda of Minnesota: *Minn G S* 3 (2): 761–812, il, 1897; Naples fauna in western New York: *Pt. I, N Y St G*, An Rp 16: 29–161, il, 1899. **Clarke, J. W.,** and **Swartz, C. K.,** Cephalopoda [U Dev of Md]: *Md G S, M and U Dev.*: 690–699, il, 1913. **Croneis, C. G.,** Unusual Carboniferous cephalopods: *Science* 64: 622–623, 1926; New cephalopods from Fayetteville shale (Arkansas): *MCZ (Harvard)*, B 67: 341–352, il, 1926. **Diener, C.,** and **Kutassy, A.,** Cephalopoda triadica: *Fos Cat*, pars 8, 56: 1–836, 1913–1933. **Elias, M. K.,** Cephalopods of Pierre formation of Wallace County, Kansas, and adjacent area: *U Kan, Sc B* 21: 289–363, il, 1935. **Felix, J.,** Versteinerungen aus der mexicanischen Jura- und Kreide-formation: *Palaeontogr* 37: 140–199, 1891. **Griffin, L.,** The anatomy of *Nautilus pompilius*: *Nat Ac Sc*, Mem 8, 1900. **Hay, R.,** Notice on some new species of fossil cephalopods: *Kan Ac Sc*, Tr 13: 37–47, 1893. **Hyatt, A.,** Fossil cephalopods of the Museum of Comparative Zoology. . . [*MCZ*]: *MCZ (Harvard)*, B 3: 59–111, 1872; Genera of fossil cephalopods: *Boston Soc N H*, Pr 22: 253–338, 1883–1884; Carboniferous cephalopods: *Tex G S*, An Rp 2: 327–356, 1891; An Rp 4, pt 2: 377–474, 1893; Phylogeny of an acquired characteristic: *Am Phil Soc*, Pr 32: 349–647, il, 1894. **Kindle, E. M.,** and **Miller, A. K.,** Bibliographic Index of North American Devonian Cephalopoda: *GSA*, SP 23: 1–179, 1939. **Miller, A. K.,** A Pennsylvanian cephalopod fauna from south-central New Mexico. *JP* 6: 59–93, il, 1932. **Miller, A. K.,** and **Cline, L. M.,** Cephalopod fauna of Pennsylvanian Nellie Bly formation of Oklahoma: *JP* 8: 171–185, il, 1934; Cephalopods of Phosphoria formation of northwestern United States: *JP* 9: 281–302, 1934. **Miller, A. K.,** and **Crockford, M. M. B.,** Permian cephalopods from British Columbia: *R Soc Can*, Tr 30 (4): 23–28, 1936. **Miller, A. K.,** and **Moore, C. A.,** Cephalopods from Carboniferous Morrow group of northern Arkansas and Oklahoma: *JP* 12: 341–354, 1938. **Miller, A. K.,** and **Owen, J. B.,** A new Pennsylvanian cephalopod fauna from Oklahoma: *JP* 11: 403–422, 1937. **Morrow, A. L.,** Cephalopods from Upper Cretaceous of Kansas: *JP* 9: 463–473, 1935. **Newell, F. H.,** Niagara cephalopods from northern Indiana: *Boston Soc N H*, Pr 23: 466–486, il, 1888. **Newell, N. D.,** Some Mid-Pennsylvanian invertebrates from Kansas and Oklahoma: III, Cephalopoda: *JP* 10: 481–489, 1936. **Ohern, D. W.,** and **Maynard, T. P.,** Cephalopoda [L Dev of Md]: *Md G S, L Dev*: 487–489, il, 1913. **Prosser, C. R.,** and **Kindle, E. M.,** Cephalopoda [M Dev of Md]: *Md G S, M and U Dev*: 307–326, il, 1913. **Raymond, P. E.,** On the occurrence, in the Rocky Mountains, of an Upper Devonian fauna with *Clymenia*: *AJS* 23: 116–122, 1907. **Reeside, J. B., Jr.,** Cephalopods from lower part of Cody shale of Oregon Basin: *USGS*, PP 150: 1–19, il, 1927; Cephalopods of Eagle sandstone and related formations in western interior of United States: *USGS*, PP 151: 1–87, il, 1927. **Ruedemann, R.,** Structure of some primitive cepha-

tinct, well defined head; a circlet of eight or more tentacles surrounding the mouth; a funnel-like hyponome through which the animal can eject a stream of water and so propel itself backward; two or four gills; a highly developed nervous system; and, if not naked, an external, camerated, planispirally coiled, calcareous shell or an internal, rudimentary shell. Extinct cephalopods had straight, curved, and loosely to tightly coiled calcareous shells, often of complex internal structure, which are common as fossils and are among the best of index fossils for regional and intercontinental correlation. The class is subdivided as follows:

Subclass Nautiloidea (Tetrabranchiata)

Characterized by four gills, and represented by the single living genus, *Nautilus;* includes several orders composed of more than 300 genera and thousands of species. **Camb.?, Ord.–Recent.**

Subclass Ammonoidea

Extinct cephalopods with complicated septa; may have had four gills; represented by over 300 genera and thousands of species. **U. Sil.–Cret.**

Subclass Coleoidea (Dibranchia)

Modern dibranchiate cephalopods which are naked or have only a rudimentary internal shell; represented by a few fossils. **Trias.–Recent.**

Nautilus, the only living genus of the Nautiloidea, is also the only modern cephalopod with a typical external shell (conch), and knowledge of the soft parts and their relations to the shell is derived entirely from this genus (Griffin, 1900). The body is short and thick, and lies in the *living chamber* in such position that the under or ventral side is on the exterior of the coil (the same relation is assumed to have prevailed among extinct forms). The inner or dorsal pair of tentacles is fused into a thick *muscular lobe* or *hood*, which acts as an operculum when the animal withdraws into the shell. A calcareous *operculum* (*Aptychus* if double, *Anaptychus* if single) has been found in many ammonoids. On the ventral side of the head is a distinct muscular leaf rolled into a tube by infolding of its free edges. This ambulatory funnel or *hyponome* widens posteriorly and opens into the gill chamber. It often produces in the shell a distinct *hyponomic sinus* indicated by modification of the growth lines. The head has a pair of large eyes, a pair of powerful horny beaklike jaws with calcified tips, and a lingual ribbon or *radula* studded with numerous rows of tiny plates and hooks. These latter structures apparently are rarely fossilized.

Posteriorly the body is rounded and completely inclosed by the mantle, the base of which is prolonged into a thin, fleshy tube or *siphon* that perforates all the septa of the shell to the apex of the initial chamber (*protoconch*). This series of perforations, which exhibits great variation in fossil shells, constitutes the *siphuncle.*

The earlier cephalopods generally have straight (*orthoconic*), curved (*cyrtoconic*), or loosely coiled (*gyroconic*) shells; later and more advanced ones have the whorls in contact and usually are tightly coiled (*nautilicone* or *ammoniticone*) in planispiral manner.

Coiled shells are *evolute* if the whorls are not so deeply impressed on the preceding ones but that all are visible, and the shell is *umbilicated* if the inner whorls are visible in the central part or umbilicus; the outer whorl of *involute* shells is so deeply impressed that it conceals all earlier whorls.

The typical cephalopod shell is fundamentally an expanding, camerated, straight or coiled cone, divided into numerous compartments (*camerae*) by transverse, adapically convex partitions (*septa*), centrally or eccentrically perforated by the siphuncle. The siphuncular perforations are bordered by apically directed *siphonal funnels*, a condition described as *retrosiphonate;* by aperturally directed *siphonal collars*, in *prosiphonate* shells; or by both types. Retrosiphonate septa are characteristic of the Nautiloidea, prosiphonate of the Ammonoidea. Siphuncular funnels may form a simple tube or a series of nummuloidal swellings. The actinoceroids have the latter modified by additional deposits.

The *suture* marks the line of contact between the edge of the septum and the conch wall. It is a structure of great evolutionary importance and is commonly the basis for generic differentiation. Sutures in most nautiloids are simple, straight or slightly undulating lines which encircle the solid filling of a shell at regular or slightly increasing intervals. Occasionally, in specialized nautiloids, the suture has regularly disposed loops or *saddles*, directed aperturally, and apically bending loops designated *lobes*. These may become pronounced in the Nautiloidea but they are always simple.

In the Ammonoidea, however, the sutures invariably are composed of well developed saddles and lobes, and these often are extremely complex. They are entire in primitive types and in the young stages of more specialized forms (*goniatitic*); notched at bottom of lobe (*ceratitic*); and notched and lobed on both saddle and lobe in the most highly developed ammonites (*ammonitic*).

The suture of an ammonoid consists of an external and an internal (dorsal) part, with division at point of involution at the *umbilical shoulder*. There may be a lobe and a saddle on the umbilical shoulder. The complete *external suture* consists of a central, unpaired ventral lobe occupying the center of the

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lopods: *N Y St Mus*, B 80: 296–341, il, 1905; Cephalopoda of Beekmantown and Chazy formations of Champlain Basin: Idem 90: 389–611, il, 1906. **Schindewolf, O. H.,** Vergleichende Morphologie und Phylogenie der Anfangskammern tetrabranchiater Cephalopoden: *Abhand Preuss Geol Landesanstalt*, N F H 148, 1933. **Thomas, A. O.,** Some unique Niagaran cephalopods: *Ia Ac Sc*, Pr 22: 292–300, 1915.

outer part of the whorl or venter and flanked by numerous paired lateral lobes and saddles. The ventral lobe, absent only in early stages of most primitive genera, is modified by a dividing ventral saddle in the more specialized types. This saddle may be simple and entire, or variously notched and divided. The paired lateral saddles and lobes are numbered first, second, etc., starting from the ventral lobe. In highly complex sutures the innermost lobes and saddles lying near the umbilical margins may be designated *auxiliaries*. These are numbered progressively toward the umbilical edge, starting from the second lateral lobe. Lobes and saddles may become digitate and highly complex in the most advanced ammonoids.

The *internal suture* consists of an unpaired dorsal lobe, entire in primitive species and in the young of specialized types, but bifid or even trifid in adults of the latter; and flanking paired saddles and lobes, which are numbered from the center of the dorsum to the line of involution or to the umbilical shoulder. The outlines of the paired lobes and saddles become modified in later Paleozoic and Mesozoic species by secondary inflections or *marginals*. These latter first modify the lobes, producing bifid or trifid ones characteristic of ceratitic sutures; then later they cause crenulation of saddles, producing the complexly incised saddles of typical ammonitic sutures.

In general the degree of sutural complexity is an index of the stage reached in development of both individual (ontogeny) and race (phylogeny), but owing to a process of retardation in development or degeneration of this particular feature, descendants of a highly specialized type, occurring in a later horizon, may have a very simple type of suture. This is the case with the Cretaceous *Pseudoceratites*, which is an ammonite that never passes the ceratitic stage.

The *aperture* of nautiloid shells is generally simple, modified only by the hyponomic sinus; in some specialized forms, however, it contracts, with development of slitlike openings or sinuses, of which the longest is the hyponomic. In the ammonoids there may be periodic constriction and thickening of the aperture, and the living chamber may also contract adaperturally. Paleozoic ammonoids commonly retain a hyponomic sinus but more specialized types and later forms may have this replaced by a *ventral crest*, or even by a long projecting rostrum. *Lateral crests* and *lappets* may also develop.

The *venter* is typically rounded and unmodified, it may be narrower or broader than the *dorsum*, and it may curve to a greater or less radius than that of the whorl as a whole. Modifications are toward flattening or sharpening. Compressed forms have a sharply acute venter; but the venter may be truncated by a flat band, or by a channel bounded by sharp ridges or a row of tubercles. A solid or hollow keel, always indicative of specialization, may further modify the venter, and it may be bounded by depressed grooves or distinct channels. It is continuous in most forms, but may be broken into elongated nodes.

Cephalopod shells may be smooth, or variously ornamented with growth lines, longitudinal striations and transverse annulations, ribs, costae, etc. Ribs and costae may be simple, or they may split into two or three branches. They may also increase by intercalation. Nodes, tubercles, and even spines are sometimes developed, and various other surface features (angulations, channels interrupting the costae, frilled growth lines, etc.) may appear.

Modern cephalopods are actively swimming, floating, or crawling marine organisms; Mesozoic and Paleozoic forms are considered to have had the same habits and habitat. The large straight forms of the Paleozoic may have been sessile benthos in some instances. The presence of a hyponomic sinus has been cited as an indication of swimming habits, while crests and lappets have been interpreted as suggesting sedentary, crawling, or possibly floating habits.

Several investigators (Walther, J. M. Clarke, et al.) have suggested that shells of dead cephalopods were distributed widely by currents as pseudoplankton, and hence may have come to rest where the animal could never have lived. Such a situation accounts for the wide distribution of fossil cephalopods — a fact which makes them excellent index fossils. A modern analogy may be observed in the dibranchiate *Spirula*, which is known to gain wide distribution in the manner just described.

Subclass Nautiloidea[1]

Shells calcareous, external, straight, curved or coiled, and divided into camerae by simple retrosiphonate septa whose sutures are straight or gently curved; aperture usually has ventral hyponomic sinus and dorsal crest; septal necks generally well developed; siphuncle central, ventral but not touch-

[1] **Croneis, C. G.,** Notes on *Cycloceras* and associated genera: *AJS* (5) 12: 185–192, 1926. **Flower, R. H.,** Cherry Valley cephalopods: *B Am Pal* 22: 273–372, il, 1936; Devonian brevicones of New York and adjacent areas: *Pal Americana* 2 (9): 1–84, il, 1938; Study of the Pseudorthoceratidae: Idem 2 (10): 1–214, il, 1939; *Harrisoceras*, a new structural type of orthochoanitic nautiloid: *JP* 13: 473–480, il, 1939; Structure and taxonomic position of *Troedssonoceras* Foerste: *JP* 13: 481–484, il, 1939. **Flower, R. H.,** and **Caster, K. E.,** Cephalopod fauna of Conewango series of Upper Devonian in New York and Pennsylvania: *B Am Pal* 22: 1–74, il, 1935. **Foerste, A. F.,** Notes on Arctic Ordovician and Silurian cephalopods: *DUB, JSL* 19: 247–306, il, 1921; Silurian cephalopods of northern Michigan: *U Mich Mus Pal*, Contr 2: 19–120, il, 1924; Notes on American Paleozoic cephalopods: *DUB, JSL* 20: 193–267, il, 1924: Cephalopods of Lake Timiskaming area and related species: *CGS*, Mem 145: 64–124, il, 1925; Notes on cephalopod genera: coiled Silurian forms: *DUB, JSL* 21: 1–69, il, 1925; Cephalopods from Devonian of southwestern Ellesmereland: *Rp 2nd Norwegian Arctic Exped in "Fram"* 1898–1902, np 39, *Det Norske Videnskaps-Akademi i Oslo* 1–12, 1926; Cephalopoda from Ordovician and Silurian of Great Slave Lake: *CGS*, B 44: 65–72, il, 1926; Actinosiphonate, trochoceroid, and other cephalopods: *DUB, JSL* 21: 285–383, il, 1926; Ordovician and Silurian cephalopods

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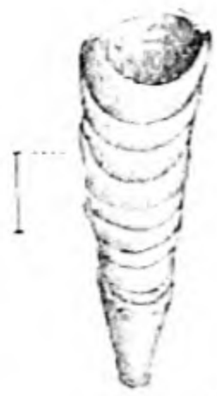

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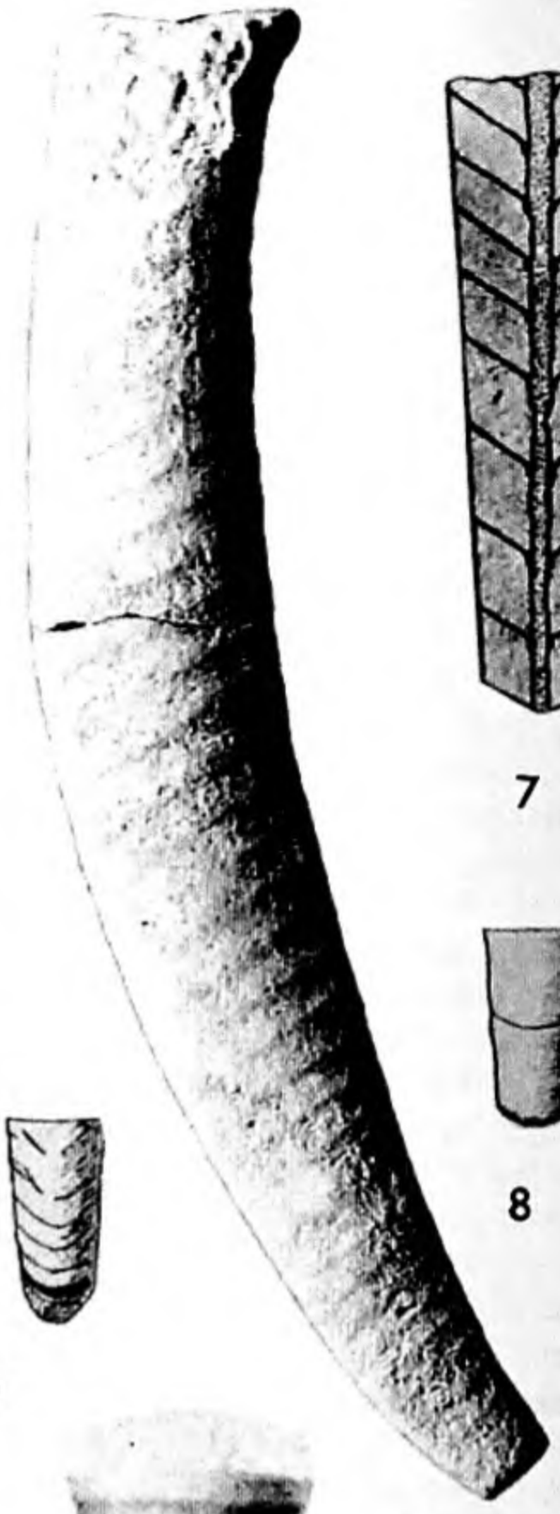

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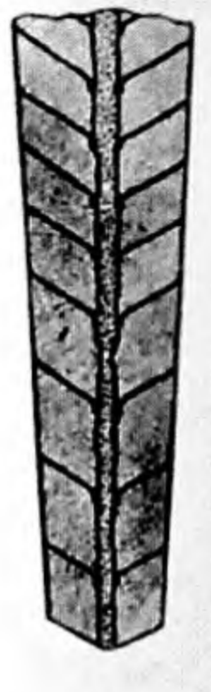

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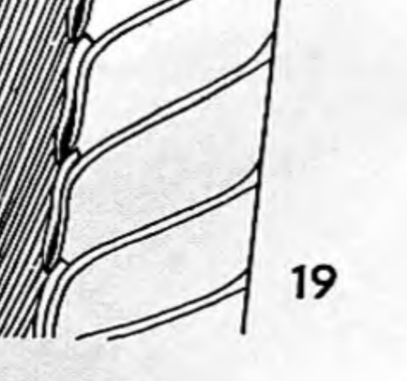

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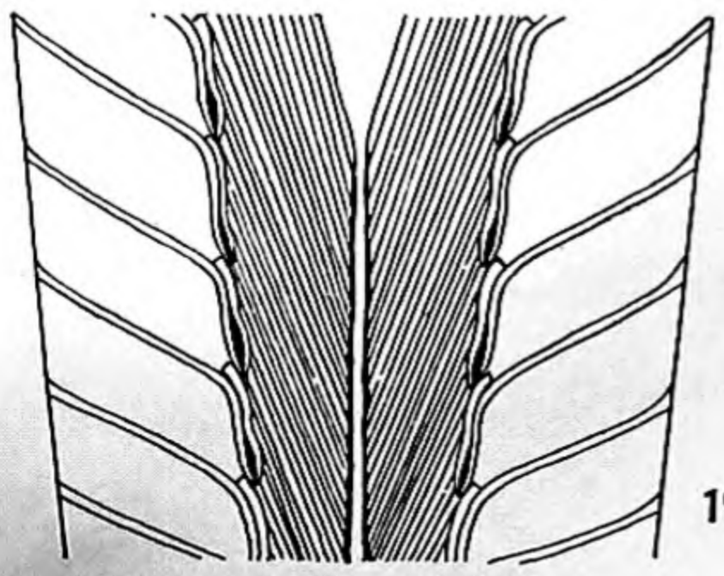

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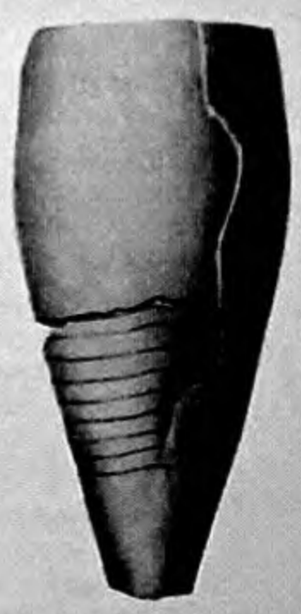

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ing ventral conch wall, touching ventral wall, or dorsal. **Camb.?, Ord.–Recent.**

Order Protochoanites. Primitive orthoconic cephalopods. **Camb.**

VOLBORTHELLA[1] Schmidt 1884

(**V. tenuis*). Minute, primitive orthoceracones with expanded living chamber, conical septa, and small empty siphuncle; may not be a cephalopod. **L.** and **M. Camb.**

***V. tenuis** Schmidt (**217**—6–8). **Camb.:** N. B. (Protolenus beds); Europe.

SALTERELLA Billings 1861

(**S. rugosa*). Small, elongate, conical tubes, straight or slightly curved, consisting of several hollow cones placed one within another, the last one forming the living chamber; transverse section circular or subtriangular. **Camb., Ord.** (Labrador, Que.; Vt., Mass., Tenn.; Europe).

***S. rugosa** Billings (**217**—2). **L. Camb.:** Labrador.

S. pulchella Billings (**217**—4). **L. Camb.:** Labrador, Que.; Vt.

S. curvata Shaler and Foerste (**217**—3). **L. Camb.:** Labrador; Que.; Mass.

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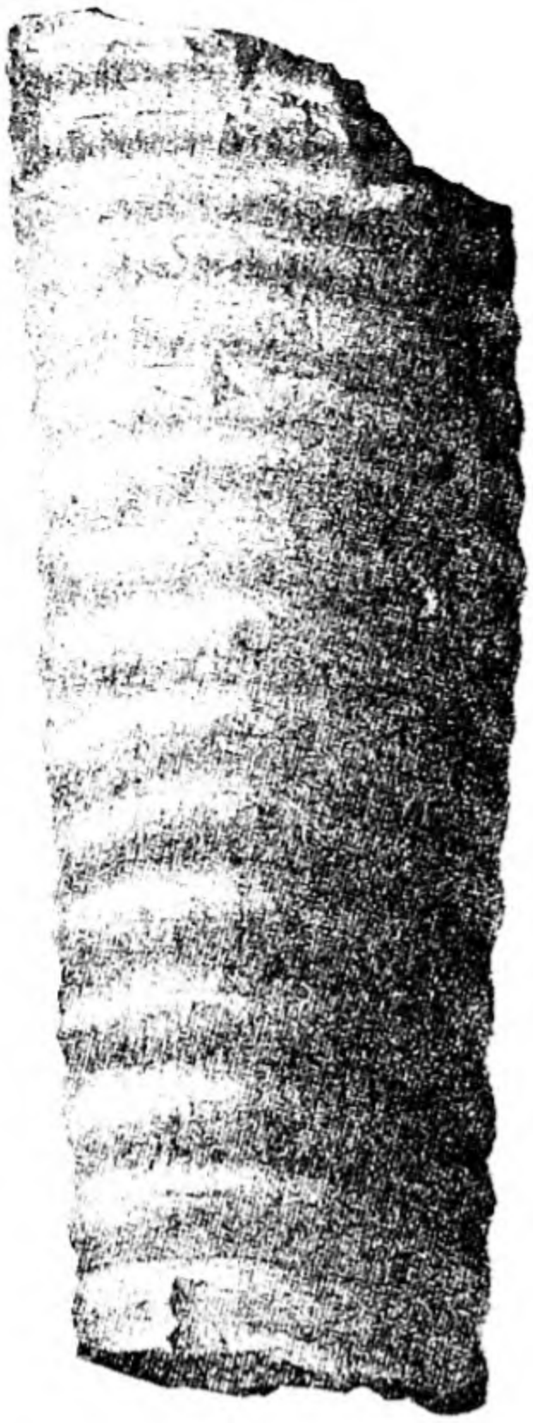
of Hudson Bay area: Idem 22: 1–107, il, 1927; Devonian cephalopods from Alpena in Michigan: *U Mich Mus Pal*, Contr 2: 189–208, il, 1927; American Arctic and related cephalopods: *DUB, JSL* 23: 1–110, il, 1928; Restudy of Ordovician and Silurian cephalopods described by Hall: Idem: 173–230, il, 1928; Contributions to geology of Foxe Land, Baffin Island, Pt II, Cephalopods of Putnam Highland: *U Mich Mus Pal*, Contr 3: 25–70, il, 1928; Restudy of American Orthoconic Silurian cephalopods: *DUB, JSL* 23: 236–320, il, 1928; Devonian cephalopods from Moose River Basin: *Ont Dp Mines*, An Rp 37: 70–78, 1929; Cephalopods of Red River formation of southern Manitoba: *DUB, JSL* 24: 192–235, il, 1929; Three studies of cephalopods: Idem: 265–381, il, 1930; *Nephriticerina*: *U Mich Mus Pal*, Contr 3: 151–154, 1930; Port Byron and other Silurian cephalopods: *DUB, JSL* 25: 1–124, il, 1930; Black River and other cephalopods from Minnesota, Wisconsin, Michigan, and Ontario: Idem 27: 47–147, il, 1932; 28: 1–146, il, 1933; Silurian cyrtoconic cephalopods from Ohio, Ontario, and other areas: Idem 29: 107–193, il, 1934; Bighorn and related cephalopods: *Idem* 30: 1–96, il, 1935; Cephalopods of Maquoketa shale of Iowa: *Idem*: 231–258, 1935; Silurian cephalopods of Port Daniel area on Gaspé Peninsula, in eastern Canada: *Idem* 31: 21–92, il, 1936; Cephalopods from Upper Ordovician of Percé, Quebec: *JP* 10: 373–384, il, 1936; Cephalopoda [in **Twenhofel's** "Geology and Paleontology of the Mingan Islands"]: *GSA*, SP 11: 76–105, il, 1938. **Foerste, A. F.,** and **Cox, I. H.,** Cephalopods from Akpatok Island: *G Mag* 73: 289–307, 1936. **Foerste, A. F.,** and **Teichert, C.,** Actinoceroids of east-central North America: *DUB, JSL* 25: 201–296, il, 1930. **Hyatt, A.,** Remarks on the genus *Nanno* Clarke: *Am G* 16: 1–12, 1895. **Leith, E.,** *Lambeoceras lambei* from Garson, Manitoba [Abst]: *GSA*, B 50: 1965, 1939. **McKelvey, V. E.,** An Ordovician *Zitteloceras* from Wisconsin: *JP* 13: 74–76, 1939. **Miller, A. K.,** Cephalopods of Bighorn formation of Wind River Mountains of Wyoming: *Conn Ac Arts Sc*, Tr 31: 193–297, il, 1932; Mixochoanitic cephalopods: *U Iowa Stud N H* 14: 1–56, 1932; Mixochoanitic cephalopod from Iowa: *AJS* (5) 26: 178–182, 1933; Cephalopods of Tully formation in central Pennsylvania: *GSA*, B 48: 1253–1255, 1937. **Miller, A. K., Dunbar, C. O.,** and **Condra, G. E.,** Nautiloid cephalopods of Pennsylvanian system in Midcontinent region: *Neb G S*, B 9: 1–240, il, 1933. **Miller, A. K.,** and **Flower, R. H.,** A *Sporadoceras* from America: *JG* 44: 751–757, 1936. **Miller, A. K.,** and **Furnish, W. M.,** Ordovician cephalopods from Black Hills, South Dakota: *JP* 11: 535–551, il, 1937; Lower Mississippian nautiloid cephalopods of Missouri: *U Mo Stud* 13: 149–178, il, 1938; Aturias from Tertiary of Mexico: *JP* 12: 149–155, il, 1938. **Miller, A. K.,** and **Owen, J. B.,** Cherokee nautiloids of northern Midcontinent region: *U Iowa Stud N H* 16: 187–272, il, 1934. **Miller, A. K.,** and **Thomas, H. D.,** Casper formation (Pennsylvania) of Wyoming and its cephalopod fauna: *JP* 10: 715–738, il, 1936. **Miller, A. K.,** and **Thompson, M. L.,** Nautiloid cephalopods of Midway group: *JP* 7: 298–324, il, 1933; Aturoidea in America: *JP* 9: 563–571, 1935. **Schenck, H. G.,** *Aturia* from western North America: *U Cal Dp g s*, B 19: 435–490, 1931. **Stenzel, H. B.,** *Aturia* from Eocene of Texas and Alabama: *JP* 9: 551–562, 1935. **Teichert, C.,** Der Bau der actinoceroiden Cephalopoden: *Palaeontogr* 78, Abt B, Stuttgart, 1933; On systematic position of *Discosorus* Hall and related genera: *Am Mus Nov* 512, 1931; Untersuchungen an actinoceroiden Cephalopoden aus Nordgrönland: *Med om Grönland* 92: 1–48, 1934; Structures and phylogeny of actinoceroid cephalopods: *AJS* (5) 29: 1–23, il, 1935. **Teichert, C.,** and **Miller, A. K.,** What is *Orthoceras?*: *AJS* (5) 31: 352–362, 1936. **Troedsson, G. T.,** On the Middle and Upper Ordovician faunas of Northern Greenland, I, Cephalopods: *Jubiliaeumsekspeditionen Nord om Grönland*, 1920–1923, B 71: 1–157, il, 1926. **Ulrich, E. O.,** and **Foerste, A. F.,** Notes on the Schistochoanites [Abst]: *GSA*, Pr 1933: 339, 1934; New genera of Ozarkian and Canadian cephalopods: *DUB, JSL* 30: 259–290, il, 1935. **Ulrich, E. O., Foerste, A. F., Miller, A.,** and **Furnish, W. M.,** Ozarkian and Canadian cephalopods, Pt I: Nautilicones: *GSA*, SP 37: 1–157, pl 1–57, 1942. **Vokes, H. E.,** Nautiloid cephalopods from Eocene of California: *JP* 11: 3–9, 1937. **Whiteaves, J. F.,** Orthoceratidae of Trenton limestone of Winnipeg Basin: *R Soc Can*, Tr 9 (4): 77–90, 1892; Canadian species of *Plectoceras* and *Barrandeoceras*. *CGS, Pal Fos* 3: 299–321, il, 1906.

[1] Miller (1932, 10–15) fully discusses the taxonomic position of the related genera *Volborthella* and *Salterella*, pointing out the diversity of opinion on this problem among numerous investigators. It seems best, at least for the present, to assign these two early genera to the Protcchoanites, though this assignment is made with full realization that future work may show that this is incorrect and that Protochoanites is not a valid order.

PLATE 217

[Figures are x1 unless otherwise indicated.]

1–4. Salterella spp. **1. S. billingsi** (x2) [Tenn G S, B 38]. **2. S. rugosa** (x5) [USGS, B 30]. **3. S. curvata** (x1.5) [MCZ (Harvard), B 16]. **4. S. pulchella** (x2) [USGS, B 30]. **5. Clarkoceras newtonwinchelli** [Minn G S 3 (2)]. Lateral view. **6–8. Volborthella tenuis.** 6, 8: Enlarged specimens (x3) [N Y Ac Sc, Tr 14]. 7: Longitudinal section [U Iowa Stud N H 14]. **9. Kirkoceras arcuatum** [DUB, JSL 30]. Siphuncle with ventral outline on right, showing septal annulations sloping downward in dorsad direction. **10, 11. Protocycloceras lamarcki** [N Y St Mus, B 90]. Exterior, transverse section, and natural longitudinal section. **12. Mcqueenoceras jeffersonense** [DUB, JSL 30]. Lateral view with slightly convex dorsal outline on right. **13. Ectenolites subgracile** [DUB, JSL 30]. Lateral view of conch with venter on right. **14–16. Orygoceras cornu-oryx** [AMNH, B 1] **17–19. Endoceras proteiforme.** 17, 18: Siphuncle and part of camerae preserved, and cross section showing diameter of young shell (inner), of siphuncle and of adult shell (x0.3) [Pal N Y 1]. 19: Diagrammatic section showing extent of septal funnels, endosiphosheaths, and endosiphotube, expanding above in endosiphocone [Hyatt]. **20. Endoceras fulgur** (x0.5) [JP 11]. **21–23. Cyclostomiceras cassinense** (x0.5) [N Y St Mus, B 90]. Ventral, dorsal, and lateral views and cross section.



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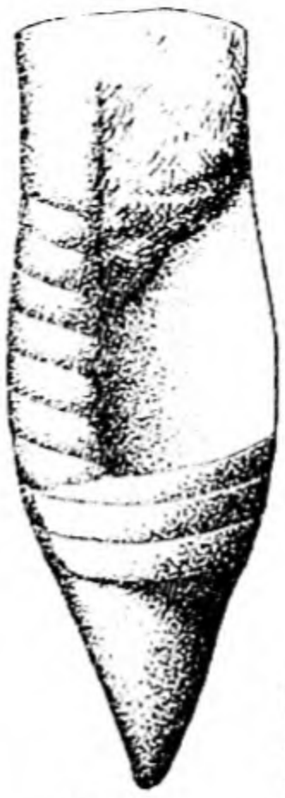

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S. billingsi Safford (**217**—1). **M. Ord.:** Ind. (Black River), Tenn. (Murfreesboro)

Order Holochoanites. Conchs orthoconic, cyrtoconic, or gyroconic; septal necks extend from septum of origin to or beyond preceding septum; siphuncle usually large, more or less filled with calcareous conical sheaths centrally perforated by an endosiphon; camerae without calcareous fillings. **Ord.–Sil.**

CLARKOCERAS Ruedemann 1905

(**Piloceras newton-winchelli* Clarke). Conch breviconic, laterally compressed, moderately curved lengthwise; ventral outline concave, dorsal more strongly convex; transverse section subovate; sutures curved downward laterally, but rising at increasing rate dorsad so that dorsal saddles are at conspicuously higher elevations than ventral ends of same sutures; siphuncle varies greatly in size, usually large, transversely circular to elliptical, endogastric. **L. Ord.** (Arctic America; Wis., Minn., Ia.).

***C. newton-winchelli** (Clarke) (**217**—5). **Oneota:** Wis., Minn., Ia.

ECTENOLITES Ulrich and Foerste 1935

(**E. subgracile*). Conchs slender, laterally compressed, curved; living chamber usually less than a third of phragmocone length; camerae shallow and numerous; sutures curving downward laterally, saddles rising higher ventrally than dorsally; septa distinctly concave; siphuncle near or touching ventral wall, small, and containing long, slowly tapering but truncated endocones; siphuncular segments with straight or slightly concave vertical outlines. **L. Ord.**

***E. subgracile** U and F (**217**—13). **Gasconade:** Mo.

KIRKOCERAS Ulrich and Foerste 1935

(**K. arcuatum*). Siphuncles distinctly curved lengthwise, touching concave ventral conch outline with smooth contact area; cross-section of siphuncle circular to distinctly compressed laterally; lateral and dorsoventral diameters enlarge distinctly along lower half of siphuncle, then contract farther up; siphuncle obliquely annulated, annulations being fairly distinct along dorsal half of siphuncle and more distinct ventrolaterally, but disappearing along contact of siphuncle and ventral conch wall; siphuncle filled with endocones, filling of uppermost endocone by matrix, forming spiculum. **L. Ord.**

***K. arcuatum** U and F (**217**—9). **Manitou:** Colo.

MCQUEENOCERAS Ulrich and Foerste 1935

(**M. jeffersonense*). Conchs short, enlarging rapidly, apparently slightly curved lengthwise, with ventral outline straight and dorsal slightly convex; compressed laterally; sutures directly transverse dorsally and ventrally, or sloping downward in ventrad direction at small angle; camerae short, numerous; siphuncle very near and at one point touching ventral conch wall; spiculum touching inner siphuncle wall along a diagonal line; dorsal side adnate to dorsal siphuncle wall almost as far down as tip of spiculum. **L. Ord.**

***M. jeffersonense** U and F (**217**—12). **Jefferson City:** Mo.

PROTOCYCLOCERAS Hyatt 1900

(**Orthoceras lamarcki* Billings). Annulated orthoceracones and cyrtocones with longitudinal markings after earlier stages, but with large siphuncle which is near or touching ventral conch wall. **L. Ord.** (Greenland; Arctic America; Newf.; Anticosti; Mingan Islands and Que.; Vt., N. Y., Utah).

***P. lamarcki** (Billings) (**217**—10, 11). **Canadian:** Greenland; Newf.; Anticosti; Mingan Islands (Romaine); Que.; N. Y. (Beekmantown).

ORYGOCERAS Ruedemann 1906

(**Orthoceras cornu-oryx* Whitfield). Orthocones with subcircular or oval section; annulations only internal; siphuncle eccentric and tubular. **L. Ord.**

***O. cornuoryx** (Whitfield) (**217**—14–16). **Canadian:** Vt. (Fort Cassin), N. Y. (Beekmantown).

CYCLOSTOMICERAS Hyatt 1900

(**Gomphoceras cassinense* Whitfield). Conch subfusiform, greatest diameter about midheight of living chamber, lengthwise curvature of dorsal side greater than ventral; siphuncle endogastric, segments presenting concave vertical outlines within camerae; septal funnels curve backward a distance equal to one camera. **L. Ord.** (Vt., Minn.).

***C. cassinense** (Whitfield) (**217**—21–23). **Ft. Cassin:** Vt.

ENDOCERAS Hall 1844

(**E. proteiforme*). "Form genus"; holochoanoidal

PLATE 218

[Figures are x1 unless otherwise indicated.]

1, 2. Cyclendoceras annulatum (x0.5) [Pal N Y 1]. Exterior view, and section showing siphuncle and septa. **3, 4. Nanno aulema** [Minn G S 3 (2)]. Part of shell showing preseptal sipho and camerae and siphuncle; filling of siphuncle. **5, 6. Vaginoceras oppletum** [N Y St Mus, B 90]. Fragment showing apical end of endosiphocone and the endosiphosheaths; enlargement of part of siphuncular wall showing structure and extent of septal funnels (x5). **7, 8. Cameroceras tenuiseptum** (x0.5) [N Y St Mus, B 90]. Fragmental shell; natural section showing endosiphotube. **9. Ascoceras croneisi** (x3) [DUB, JSL 25]. Lateral view. **10. Clitendoceras sayiesi** [DUB, JSL 30]. Lateral view with ventral outline on right. **11–14. Proterocameroceras brainerdi.** 11: Diagrammatic section of early growth stage [N Y St Mus, B 80].12–14: View of siphonal side of shell, and two views of end showing siphuncle and convexity of septa [AMNH, B 1]. **15. Cotteroceras compressum** [DUB, JSL 30]. Lateral view with ventral outline on left. **16. Schuchertoceras anticostiense** [CGS, M 154]. Lateral view. **17. Cassinoceras explanator** (x0.5) [AMNH, B 1]. Lateral view of lower end of conch with siphuncle protruding. **18. Billingsites canadensis** [CGS, M 154]. Lateral view.

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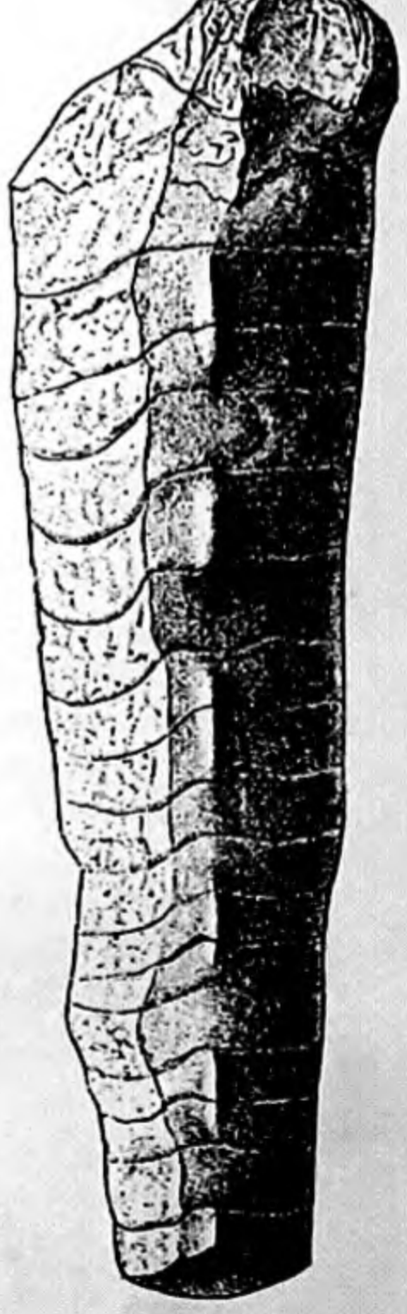

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Diagrammatic sections showing differences between (A) *Michelinoceras*, in which the secreting surface is continuous, and (B) *Harrisoceras* in which it is discontinuous. *C*, wall of conch; *M*, mural part of septum; *F*, free part of septum; *N*, septal neck; *E*, episeptal deposits; *H*, hyposeptal deposits; *A*, annulosiphonate deposits of siphuncle; *CR*, connecting ring.

orthocones in which endocones are long, funnel-like, few, and distant from each other, and without trace of annulations; conch surface free of annulations; typically, diameter of siphuncle compared with that of conch is relatively large. **Ord.** (widely distributed throughout N. America — Greenland, Arctic America, Canada, and U. S. A.)–**Sil.**

***E. proteiforme** Hall (**217**—17–19). Conchs large (as much as 3 m, or 10 to 12 ft, long); siphuncle large, submarginal; siphonal funnels short, scarcely reaching next septum. **M.** and **U. Ord.** (widely distributed throughout N. America).

E. fulgur (Billings) (**217**—20). **U. Ord.:** Anticosti (English Head); Man. (on Shamattawa River); S. Dak. (Whitewood), Wyo. (Lander).

CYCLENDOCERAS Grabau and Shimer 1910

(**Endoceras annulatum* Hall). Like *Endoceras*, but with annulated surface. **M.** and **U. Ord.** (Greenland; Arctic America; N. Y., Ia.; Man.; S. Dak., Wyo.).

***C. annulatum** (Hall) (**218**—1, 2). Large; septa deeply concave; siphuncle large, subdorsad, circular in section. **Trenton:** N. Y.; Man.

CAMEROCERAS Conrad 1842

(**C. trentonensis*). "Form genus"; differs from *Endoceras* chiefly in shortness and greater obliquity of its endocones, which tend to be distinctly annulated in a direction parallel to adjacent oblique part of septa. **Ord.** (Que.; Vt., N. Y.; Ont.; Ohio, Ind., Ill.; Man.; Minn., Mo.).

C. tenuiseptum (Hall) (**218**—7, 8). **Chazy:** Vt., N. Y.

NANNO Clarke 1894

(**N. aulema*). Like apical end of *Endoceras*, with which it may be congeneric, consisting of preseptal cone continuing upward as the siphuncle; ventral outline slightly but distinctly convex. **M. Ord.** (Ont.; N. Y., Minn., Colo.)

***N. aulema** Clarke (**218**—3, 4). **Black River:** Minn. (Decorah).

PROTEROCAMEROCERAS Ruedemann 1905

(**Orthoceras brainerdi* Whitfield). Like *Cameroceras*, but with a large preseptal cone or nepionic bulb. **L. Ord.** (Vt., N. Y.).

***P. brainerdi** (Whitfield) (**218**—11–14). **L. Ord.:** Vt. (Ft. Cassin), N. Y. (Valcour).

VAGINOCERAS Hyatt 1883

(**Endoceras multitabulatum* Hall). Like *Endoceras*, but with numerous endocones. **Ord.** (Greenland; Vt., N. Y.).

V. oppletum Ruedemann (**218**—5, 6). Large (a meter or more), slowly expanding; subcircular in section, with large living chamber, shallow camerae increasing progressively (20 mm in adult); older ones with organic deposits often filling them; sutures with ventral saddle; siphuncle circular, two-fifths conch diameter, subventran; surface smooth. **Chazyan:** Vt., N. Y.

CLITENDOCERAS Ulrich and Foerste 1935

(**C. saylesi*). Orthoconic holochoanoidal conchs with nearly circular transverse section; camerae relatively short and numerous; sutures nearly straight but sloping from dorsal side downward in a ventral direction; siphuncle very close to and apparently touching ventral wall. **L. Ord.**

***C. saylesi** U and F (**218**—10). **Ft. Cassin:** N. Y.

COTTEROCERAS Ulrich and Foerste 1935

(**C. compressum*). Differs from *Clitendoceras* chiefly in lateral compression of conch; siphuncle relatively large and touching ventral wall; endocones relatively short. **L. Ord.**

***C. compressum** U and F (**218**—15). **L. Ord.:** Minn. (Shakopee), Mo. (Cotter).

CASSINOCERAS Ulrich and Foerste 1935

(**Piloceras explanator* Whitfield). Ventral outline almost straight, basal part sometimes slightly convex; dorsal outline, on contrary, conspicuously convex and strongly divergent from ventral; siphuncle usually distinctly compressed laterally, its transverse section more narrowly rounded ventrally than dorsally. **L. Ord.**

***C. explanator** (Whitfield) (**218**—17). **L. Ord.:** Vt. (Ft. Cassin), N. Y. (Valcour).

Order Mixochoanites. Conch orthoconic or cyrtoconic, with expanded living chamber and contracted aperture; dorsal to the large living chamber is a series of vacant chambers without siphuncular connection; septa generally oblique to shell axis, siphuncle in specialized forms has short, straight septal necks in young stages, but in adults collars are built around the siphuncular perforation — a development also present in some goniatites. **U. Ord.–Sil.**

BILLINGSITES Hyatt 1884

(**Ascoceras canadense* Billings). Differs from related genera in that its gerontic ovoid cluster of living chambers is depressed dorsoventrally instead of laterally; also upper part of cluster tends to be less elongated beyond that part of conch which equals

PLATE 219

[Figures are x1 unless otherwise indicated.]

1–6. Michelinoceras spp. **1, 2. M. multicameratum** [Pal N Y 1]. Exterior, and longitudinal section. **3. M. subulatum** [Pal N Y 5]. A crushed but complete specimen. **4–6. M. sociale** [DUB, JSL 30]. **7, 8. Geisonoceras filosum** [Md G S, Dev]. **9. Geisonocerina wauwatosense** [DUB, JSL 23]. Filling of living chamber. **10–12. Michelinoceras** spp. **10, 11. M. clarkesvillense** [DUB, JSL 20]. Internal filling and natural section showing parts of siphuncle. **12. M. pelops** (x0.5) [Pal N Y 5]. **13, 14. Tylorthoceras ohioense** [N Y Ac Sc, An 5]. Section showing internal structure, and specimen showing nodes. **15, 16.** Comparative diagrammatic sections of **Michelinoceras** and **Harrisoceras** [JP 13].

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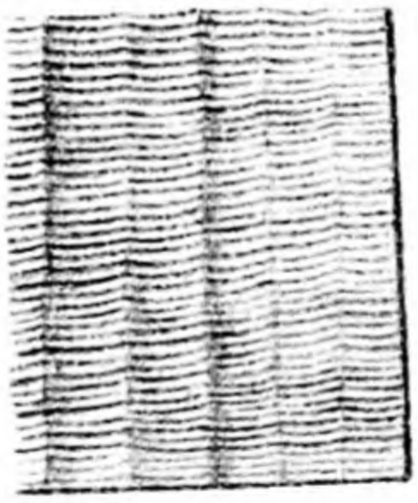

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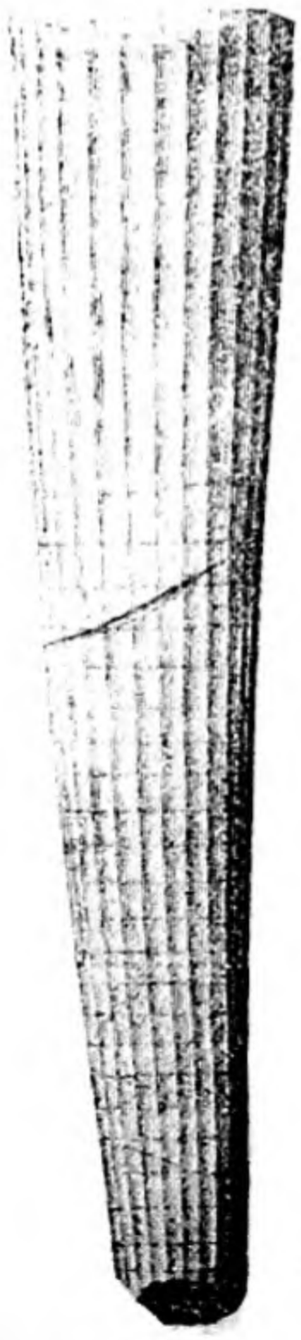

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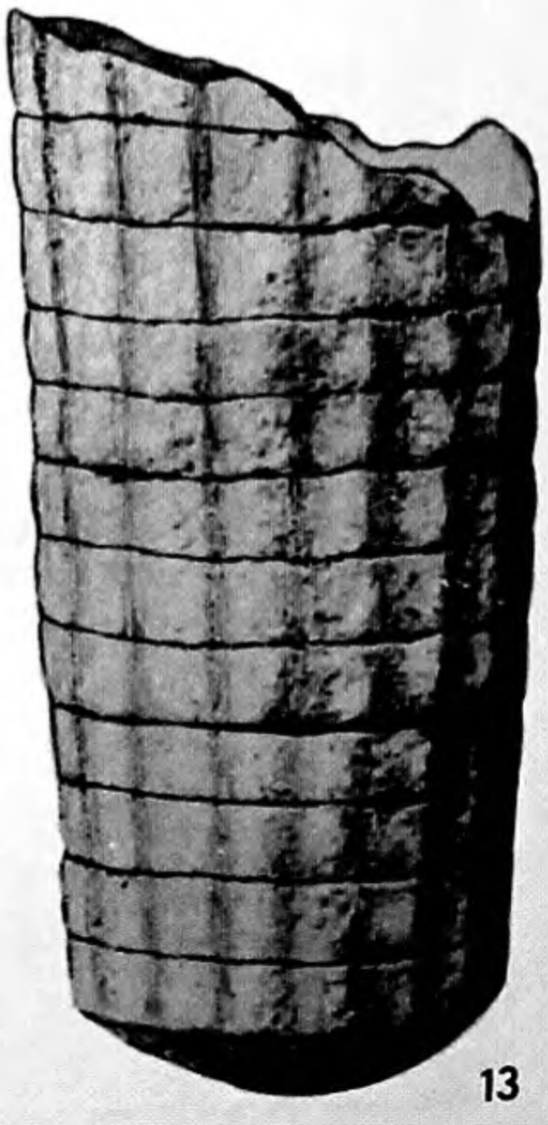

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in elevation the crest of the uppermost dorsal saddle or the sutures. **M.** and **U. Ord.** (widespread in the Hudson Bay region; Anticosti; Mich., Ohio, Ia; also in Norway, Sweden, and Estonia).

***B. canadensis** (Billings) (**218**—18). **Ord.:** Anticosti (English Head, Vaureal).

SCHUCHERTOCERAS Miller 1932

(**Ascoceras anticostiensis* Billings). Characterized by a "basal" septum between the septum of truncation and the strongly sigmoidal septa. **U. Ord.** (Anticosti; Que.; Ia.; possibly also in Mich., Ohio, Ind., Man.).

***S. anticostiense** (Billings) (**218**—16). **Richmond:** Anticosti (English Head); Que.; uppermost **Ordovician** or lowermost **Silurian** of Norway and Sweden.

ASCOCERAS Barrande 1847

(**A. bohemicum*). Conchs known chiefly from elongated gerontic sacklike expansions, including the later stages of the living chamber; these are fusiform, compressed laterally, and narrowed at the top into a cylindrical extension, the neck; septa within expansions closely crowded, approximately horizontal at siphuncle and ventrally therefrom, but dorsally they rise in form of saddles to successively higher elevations; siphuncle evidently ventrad of conch center. **Ord.?–M. Sil.** (characteristic of **Silurian,** occurring in Anticosti; Ont.; Ind., Wis., Ill., Minn.; Man.).

A. croneisi Foerste (**218**—9). **Niagaran:** Wis. (Racine).

Order Orthochoanites. Conchs orthoconic or coiled, with occasional gerontic uncoiling; septal necks tubular to slightly nummuloidal, usually longer and straigher than in Cyrtochoanites, and with posterior ends of funnels never bent sharply outward as in that order. **Ord.–Recent.**

"ORTHOCERAS"

For many years **Orthoceras** has served as a convenient "form genus" for orthoconic cephalopod shells with relatively small and nearly central siphuncle, and with apparently smooth shell surface, whose relationship to any other group could not be determined definitely. Foerste (1932, 70) so characterized the genus and created numerous new species, though he recognized that many of these were probably not congeneric. He also stated that the genotype **Orthoceratites regularis* Schlotheim was an unsatisfactory selection and that so far as he knew no species of *Orthoceras ss* occurs in North America. Flower (personal communication) has expressed agreement with the latter statement.

Teichert and Miller (1936, 352–362) have recently pointed out that *Orthoceras* was first used for a pelecypod, and later for several other organisms, before being applied to cephalopods; hence the name as a cephalopod genus must be abandoned. They propose to adopt as a substitute the name *Orthoceros*, which was introduced by Brünnich in 1771, with **Orthoceratites regularis* Schlotheim as the genotype.

It seems, then, that old familiar *Orthoceras* must be abandoned, and the many species that have been referred to it must be restudied and assigned to the proper genus. It is probable that most North American species formerly referred to *Orthoceras* should be assigned to *Michelinoceras* Foerste 1932.

MICHELINOCERAS Foerste 1932 (**219**—15)

(**Orthoceras michelini* Barrande). "Form genus"; conchs like typical *Orthoceros* Teichert and Miller 1936 (**Orthoceratites regularis* Schlotheim) with tabular siphuncle and camerae vertically elongated, but without the vertical grooves which are diagnostic of *Orthoceros*. **Ord.–Miss.** (includes many species once referred to *Orthoceras*, from many localities in Canada and U. S. A.)

M.? multicameratum Emmons (**219**—1, 2). **M. Ord.:** N. Y. (Lowville), Tenn. (Stones River), Minn.

M.? sociale Hall (**219**—4–6). Septa deeply concave, six to nine in 25 mm; siphuncle central in youth, eccentric in maturity. **M.** and **U. Ord.:** Cincinnati region (Eden, Maysville), Minn. (Trenton–Richmond), Ia. (Maquoketa).

M. clarkesvillense Foerste (**219**—10, 11). **U. Ord.** (Richmond): Mich., Ohio (Liberty or Waynesville).

M.? subulatum (Hall) (**219**—3). **Dev.:** Marcellus, Hamilton, Tully and Genesee of N. Y.; possibly Romney of Md., Pa., and W. Va.; Onondaga of Pa.; M. Dev. of Ont.; and Grand Tower of Mo.

M.? pelops (Hall) (**219**—12). **Dev.:** Schoharie of N. Y.; possibly Onondaga of Ont. and M. Dev. of N. J.

GEISONOCERAS Hyatt 1884

(**Orthoceras rivale* Barrande). Conchs transversely banded or striated; bands relatively wide and flat, their upper margins abruptly delineated, their lower apparently invaginating into tops of immediately underlying bands; siphuncle expanding but slightly within camerae. **Ord.–Dev.** (Ont.; N. Y., Md., W. Va., Ind., Wis., Ill., Minn., Ia.).

G. filosum (Clarke) (**219**—7, 8). **Dev.:** N. Y. (Naples), ?Md. and W. Va. (Jennings).

PLATE 220

[Figures are x1, and after Foerste [DUB, JSL 23] unless otherwise indicated.]

1. Ephippiorthoceras laddi [DUB, JSL 30]. **2–4. Leurocycloceras** spp. **2. L. junciforme.** Internal filling of living chamber and a few camerae. **3. L. niagarense.** Diagram of two camerae, dorsoventral section. **4. L. raymondi.** Lateral view with ventral outline on left. **5. Brachycycloceras normale** [Neb G S, B 9]. **6, 7. Striacoceras typum** [Pal N Y 5]. Well preserved specimen (x0.5) with part of shell adhering, and portion of surface much enlarged. **8. Dawsonoceras hyatti. 9. Klonoceras cancellatum** (x0.7) [N Y St Mus, An Rp 20]. **10. Dawsonoceras americanum. 11, 12. Metaspyroceras ruedemanni.** Lateral view, ventral on right; ventral view. **13. Klonoceras austini.**

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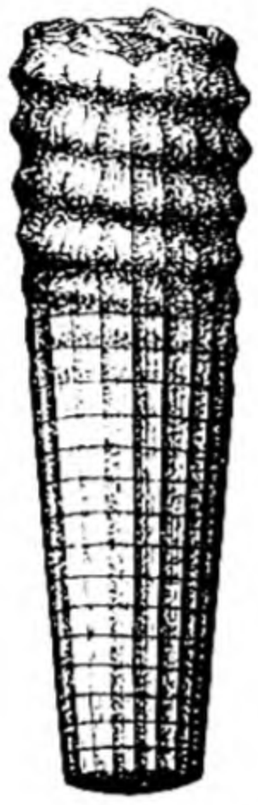

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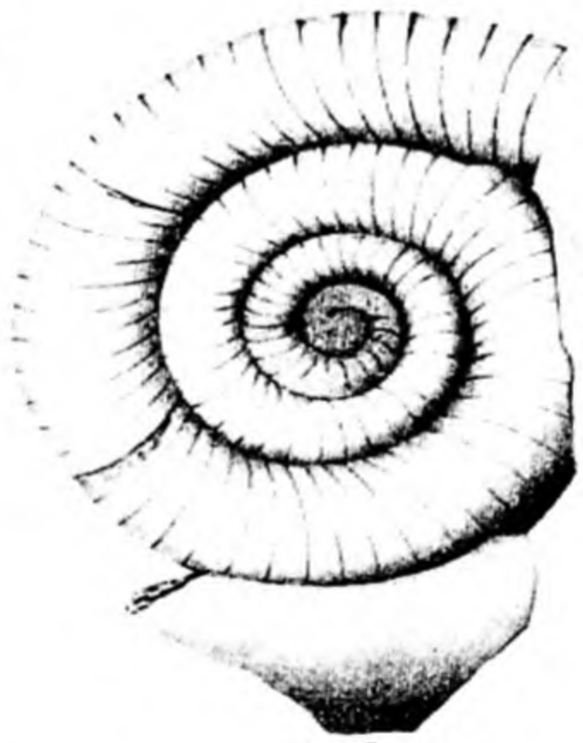

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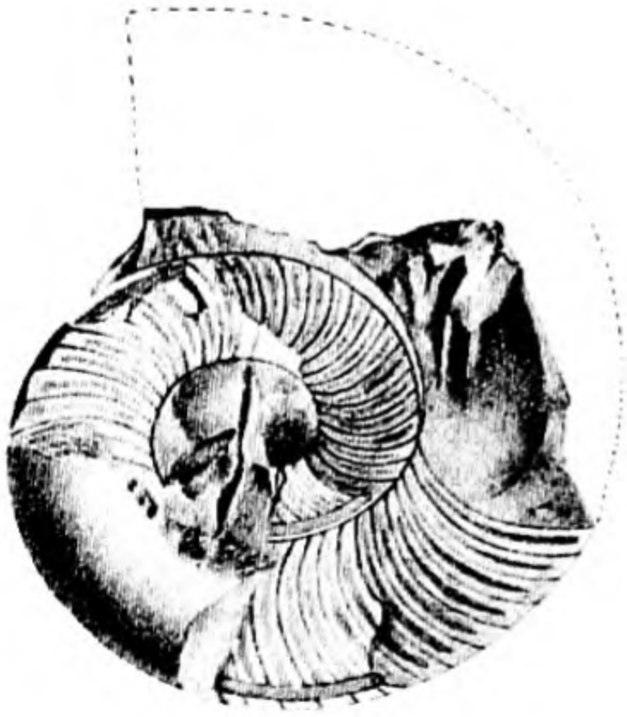

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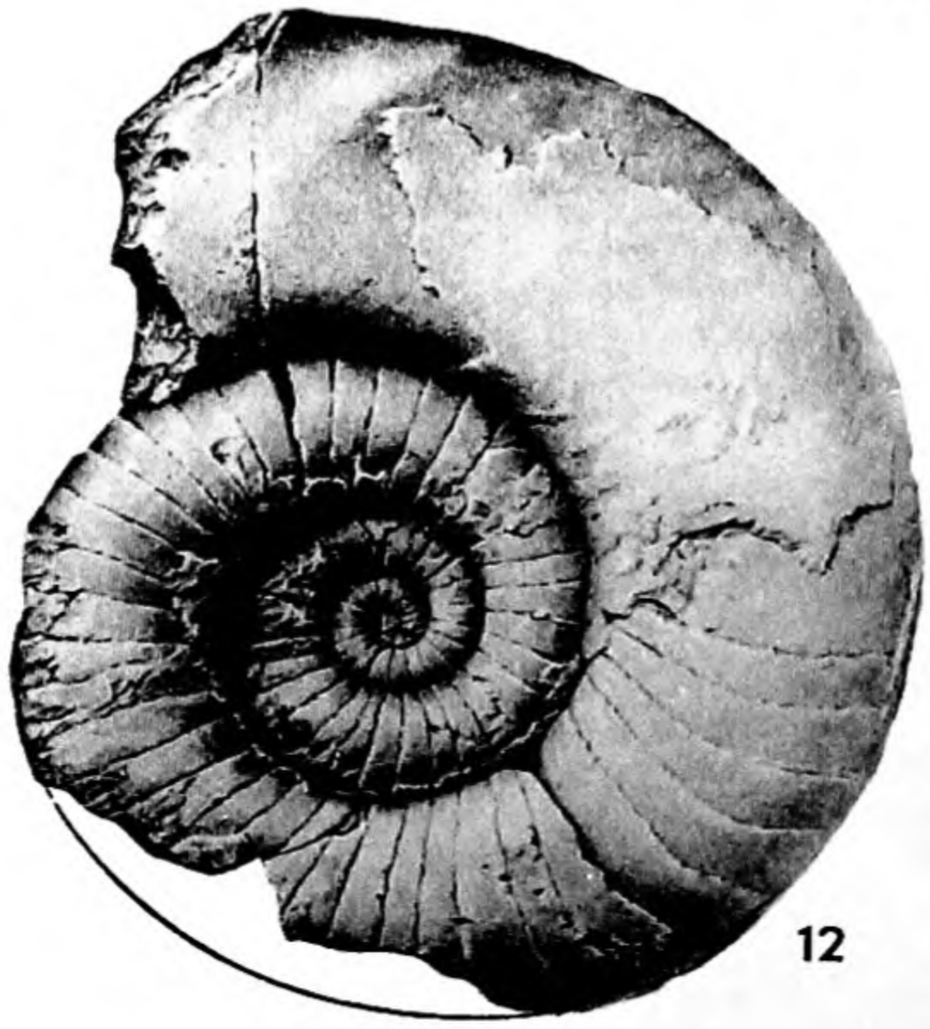

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GEISONOCERINA Foerste 1935

(**Orthoceras wauwatosense* Whitfield). Differs from typical *Geisonoceras* in having numerous close, raised transverse striae instead of comparatively broad bands. **M. Sil.** (Wis.). (Genus also reported from **Ord.** of Que. and Wyo.)

***G. wauwatosense** (Whitfield) (**219**—9). **Racine.:** Wis.

HARRISOCERAS Flower 1939 (219—16)

(**H. orthoceroides*). Orthochoanitic orthoceracones characterized by a central canal, large siphuncle, and annulosiphonate deposits which develop markedly inward. **M. Sil.** (Ind., Ill.; Europe).

***H. orthoceroides** Flower. **Niagaran:** Ill. ("Waukesha").

TYLORTHOCERAS Miller 1932

(= TREMATOCERAS Whitfield 1882)

(**Trematoceras ohioense* Whitfield). Orthoceroid, but with a series of elongate tubercles on one side, which appear to represent an interrupted series of elongate openings in the living chamber, progressively closed by shelly deposits. **Dev.**

***T. ohioense** (Whitfield) (**219**—13, 14). **M. Dev.:** Ont. (Onondaga); Mich. (Dundee), Ohio (Columbus).

EPHIPPIORTHOCERAS Foerste 1925

(**Orthoceras formosum* Billings). Orthoceroids with conspicuous lateral lobes; conchs orthoconic, with sutures curving downward laterally, and with siphuncular segments enlarging within camerae so as to present vertically elliptical or nearly spherical outlines. **M.** and **U. Ord.** (Greenland; Arctic America; E. Canada; Ia., S. Dak., Wyo., Colo., Idaho; Man.).

E. laddi Foerste (**220**—1). **Richmond:** Ia. (Maquoketa).

LEUROCYCLOCERAS Foerste 1928

(**L. raymondi*). Orthoceroids having shell surface annulated but not striated transversely or vertically. **Sil.:** Wis. (Racine). (Apparently all Silurian species formerly referred to "*Cycloceras*" should be placed in this genus.)

***L. raymondi** Foerste (**220**—4). **Racine:** Wis.

L. niagarense (Hall) (**220**—3). **Niagaran:** Wis. (Waukesha), Ill. (Racine).

L. junciforme (Foerste) (**220**—2). **Niagaran:** Ohio (Cedarville).

BRACHYCYCLOCERAS Miller, Dunbar and Condra 1933

(**B. normale*). Orthoceraconic, with adoral end of living chamber sometimes abruptly expanded; conch surface marked by narrow, transverse annulations which average about four in a distance equal to shell diameter; both annulations and spaces between finely lirate; phragmocone relatively short; septa moderately convex apicad; sutures transverse but not parallel to annulations; siphuncle small, orthochoanitic. **Penn.** (Ky., Mo., Okla., Tex.).

***B. normale** M, D and C (**220**—5). **Penn.:** Okla. (Wewoka), Tex. (Wayland, Finis, Cisco).

DAWSONOCERAS Hyatt 1884, emend Foerste 1924

(**D. hyatti* Foerste). Differs from *Cycloceras* in having frilled or wrinkled growth lines between annulations; siphuncle small. **M. Sil.–L. Dev.** (widespread and common in the Silurian throughout Arctic America, Canada, and U. S. A.).

***D. hyatti** Foerste (**220**—8). **Niagaran:** Ont. (Lockport); Ohio (Cedarville), Ill. (Port Byron).

D. americanum (Foord) (**220**—10). **Niagaran:** Ont. (Lockport); N. Y. (Rochester), Ind. (Osgood), Ky.; **L. Dev.:** Ont. and Mich. (Detroit River).

STRIACOCERAS Flower 1936

(**Orthoceras typus* Saemann). Slender orthoceracones of circular section with straight, transverse, or slightly oblique sutures; siphuncle orthochoanitic, nearer venter than dorsum; circumferential deposits within camerae; siphuncle empty; surface bearing equally spaced, transverse and longitudinal lirae in early part of shell, transverse lirae only in later stages, and finally only weak transverse striae on an otherwise smooth surface. **Dev.** (eastern N. America).

***S. typum** (Saemann) (= **Orthoceras marcellense** Hall) (**220**—6, 7). **Marcellus:** N. Y. (Cherry Valley); possibly **Hamilton** and **Tully** of N. Y. and **M. Dev.** of Ont.

KIONOCERAS Hyatt 1884

(**Orthoceras doricum* Barrande). Orthoceracones in which shell surface is vertically ribbed and fluted. **Ord.–Dev.** (widespread throughout Arctic America, Canada, and U. S. A.).

K. cancellatum (Hall) (**220**—9). **Clinton–Guelph:** N. S., Ont.; Ohio to Ill., Wis.

PLATE 221

[Figures are x1 unless otherwise indicated.]

1. Protokionoceras medullare (x0.5) [N Y St Mus, An Rp 20]. **2–7. Spyroceras** spp. **2. S. crotalum** [Pal N Y 5]. A septate fragment with sharp annulations and rapid degree of expansion. **3. S. bilineatum** [Minn G S 3 (2)]. **4, 5. S. nuntium** [Pal N Y 5]. A small specimen, and portion enlarged to show surface. **6. S. olorum** [DUB, JSL 23]. **7. S. thoas** [Pal N Y 5]. **8. Centrotarphyceras seelyi** (x0.5) [N Y St Mus, B 90]. Lateral view showing earlier volutions. **9. Aphetoceras farnsworthi** (x0.5) [GSA, SP 37]. **10. Tarphyceras multicameratum** (x0.5) [N Y St Mus, B 90]. Natural section of type. **11. Schroederoceras eatoni** (x0.5) [N Y St Mus, B 90]. Lateral view of a perfect specimen. **12. Eurystomites kelloggi** (x0.5) [GSA, SP 37]. Lateral view of type. **13. Barrandeoceras natator** (x0.5) [GSA, SP 11]. An incomplete specimen.

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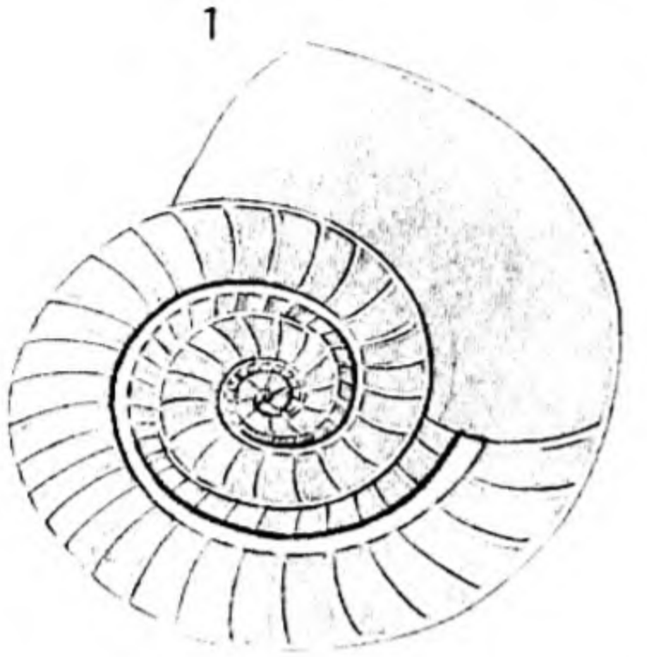

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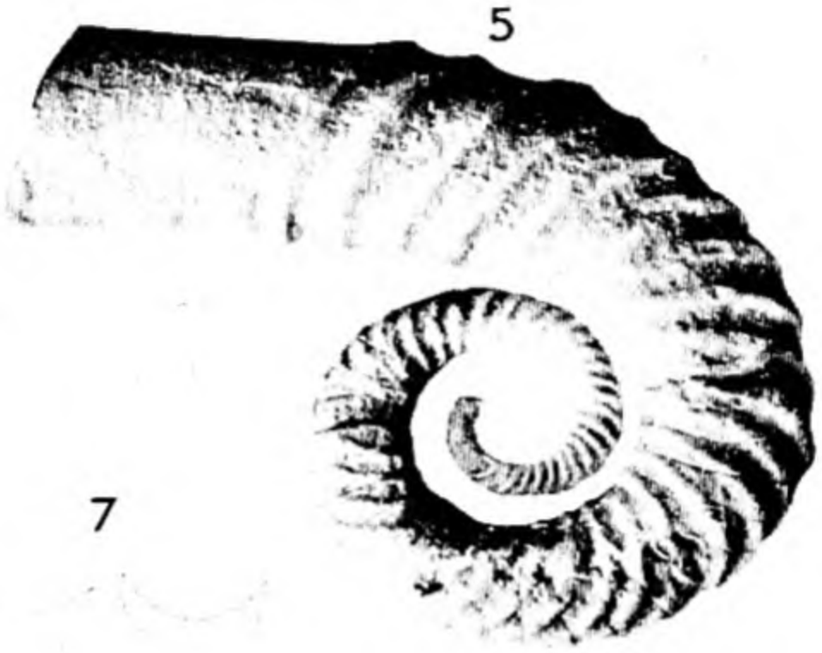

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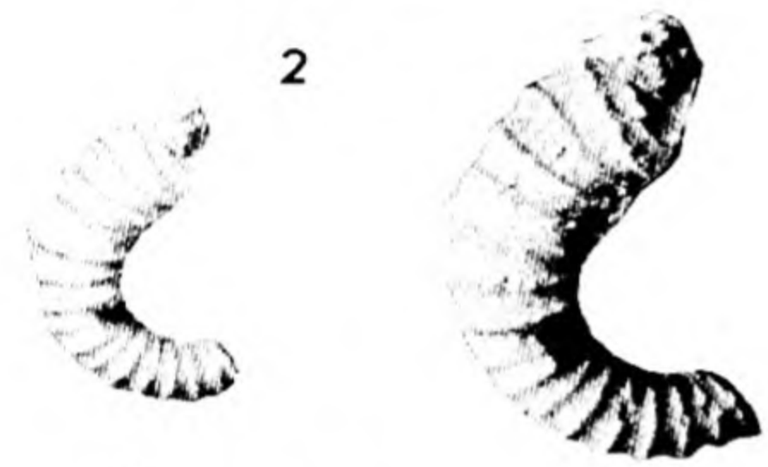

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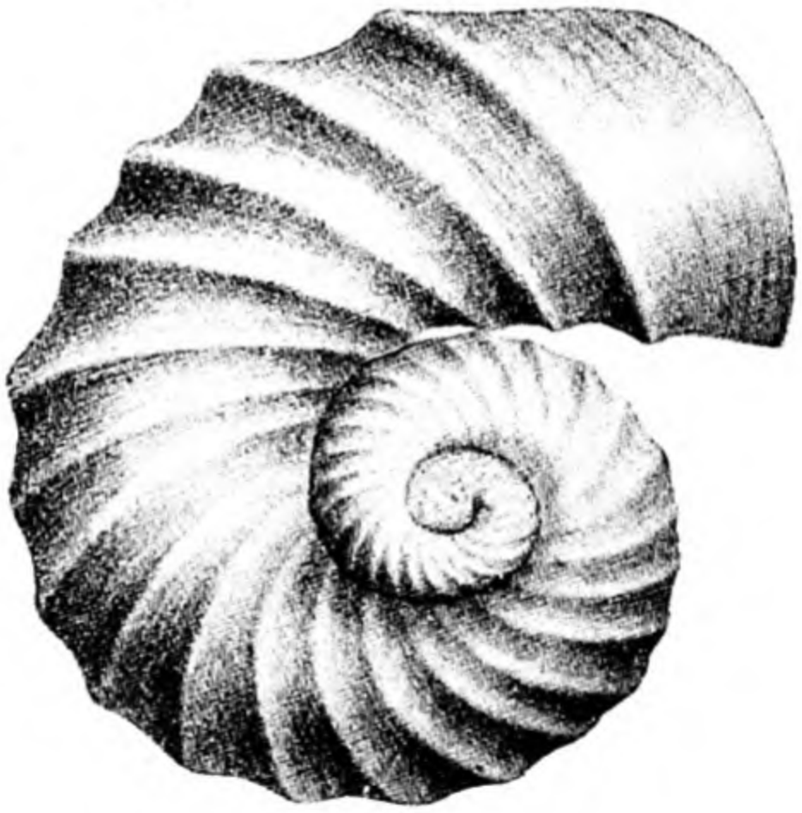

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K. austini Foerste (**220—13**). **M. Sil.:** Ohio (Cedarville).

PROTOKIONOCERAS Grabau and Shimer 1910

(**Orthoceras medullare* Hall). Nonannulated orthoceracones with surface marked by fine and generally rather close longitudinal striae; siphuncle more or less moniliform. **Sil., Dev.** (Que., Ont.; N. Y., Ind., Wis., Ill., Ark.).

***P. medullare** (Hall) (**221—1**). Large, tapering; sutures widely separated; striae fine, alternating, close together. **Clinton–Guelph:** Ont.; N. Y., Ind., Wis. (Racine), Ill. (Racine).

METASPYROCERAS Foerste 1932

(**Spyroceras ruedemanni*). Conchs short, depressed dorsoventrally, with dorsal outline nearly straight but ventral distinctly convex; sutures slope downward ventrad, while annulations rise in that direction; otherwise like *Spyroceras*. **Ord., Sil.** (Que., Ont.; Ohio, Wis., Minn.).

***M. ruedemanni** (Foerste) (**220—11, 12**). **Niagaran:** Ohio (Cedarville).

SPYROCERAS Hyatt 1884

(**Orthoceras crotalum* Hall). "Form-genus"; conchs crossed transversely by strong, sharply defined, and rather distant annulations; vertical striae very fine, closely crowded; no corresponding fine transverse striae; lineate group with vertical markings of equal strength; bilineate with markings alternately stronger and weaker, the former called ribs; cancellated group with numerous fine vertical striae crossed by about same number of fine transverse striae; scalariform group has relatively distant vertical ribs crossed by distinct and relatively large transverse raised lines; structure of siphuncle not well known. **?Ord.–Dev.** (widespread and common in Canada and U. S. A.).

"S." bilineatum (Hall) (**221—3**). **Black River–Trenton:** Que., Ont.; N. Y., Pa., Ky., Tenn., Minn., Ill., Mo.

"S." olorum (Hall) (**221—6**). **Trenton:** N. Y., S. Dak. (Whitewood), Wyo. (Lander).

***S. crotalum** (Hall) (**221—2**). **Dev.:** N. Y. and Pa. (Hamilton); possibly Tully of N. Y., Romney of W. Va. and Md., Frog Mountain and Ragland of Ala., and Ouray of Colo.; **M. Dev.:** Ont.

S. thoas (Hall) (**221—7**). **Dev.:** Scholarie–Onondaga of N. Y.; possibly Jeffersonville of Ind., Columbus of Ohio, Onondaga and Alpena of Mich., and Hamilton of Pa.

S. nuntium (Hall) (**221—4, 5**). **Dev.:** Hamilton and Tully of N. Y. and Pa.; possibly Marcellus of N. Y., Romney of W. Va. and Md.; M. Dev. of Ont.; Ohio; Germany.

TARPHYCERAS Hyatt 1894

(**T. prematurum*). Discoidal; gradually enlarging whorls in contact and slightly impressed, last whorl often diverging; siphuncle ventrad in young, subventrad later; surface smooth except for growth lines; sinus deep and broad. **L. Ord.** (Newf.; Que.; Vt., N. Y., Va.).

T. multicameratum Ruedemann (**221—10**). **Chazyan:** Vt., N. Y. (Valcour).

CENTROTARPHYCERAS Ulrich and Foerste 1935

(**Lituites seelyi* Whitfield). Dorsal side deeply impressed at contact with preceding volution; siphuncle subcentral, usually slightly ventrad of conch center; typical *Tarphyceras* has siphuncle distinctly nearer ventral conch wall. **L. Ord.** (Mingan Islands, Que.; Vt., N. Y.).

***C. seelyi** (Whitfield) (**221—8**). **Canadian:** Vt. (Ft. Cassin), N. Y. (Valcour).

EURYSTOMITES Schröder 1891

(**Nautilus kelloggi* Whitfield). Differs from *Tarphyceras* in its less discoidal form, more rapidly enlarging and less numerous whorls which embrace more strongly and are laterally compressed in adult; aperture with prominent lateral crests. **L.** and **M. Ord.** (Baffin Land; Newf.; Que.; Vt., N. Y., Va., Wis., Ill.).

***E. kelloggi** (Whitfield) (**221—12**). Living chamber free in old age; sutures with broad lateral lobes in adult; siphuncle tubular, subventrad. **Canadian:** Vt. (Ft. Cassin), N. Y. (Valcour), Wis. and Minn. (Shakopee).

APHETOCERAS Hyatt 1894

(**A. americanum*). Gyroceraconic, compressed oval in section, venter narrower than dorsum; siphuncle empty, tubular and ventrad of center. **L. Ord.** (Newf.; Que.; Mo.).

A. farnsworthi (Billings) (**221—9**). **Beekmantown:** Que.

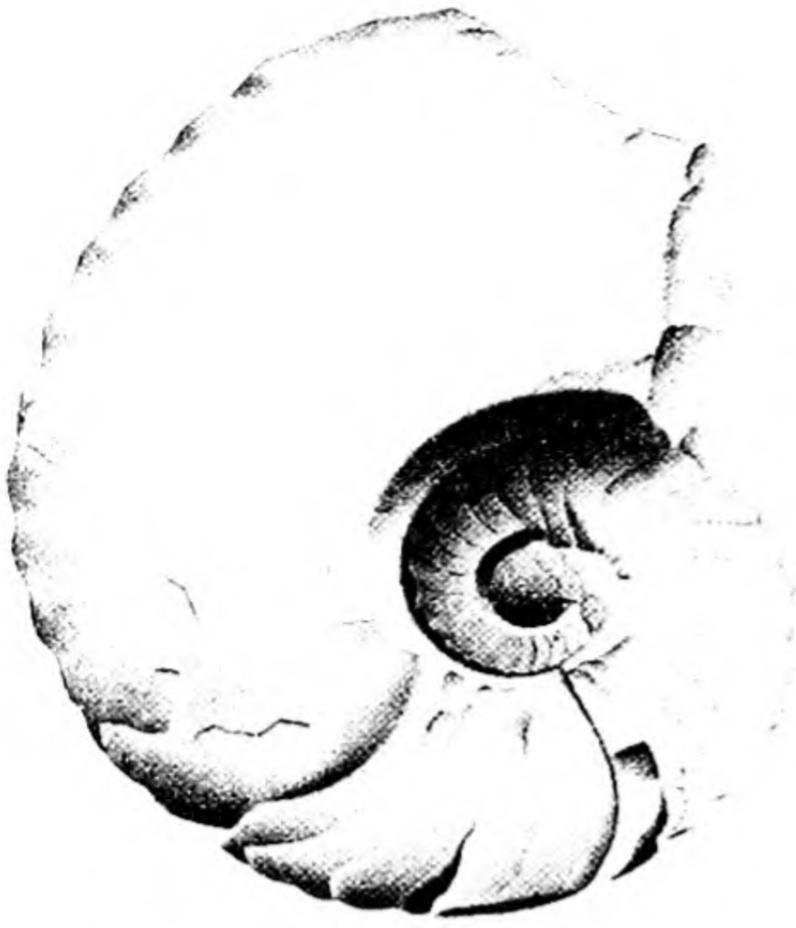
SCHROEDEROCERAS Hyatt 1894

(**Lituites angulatum* Saemann). Differs from *Tarphyceras* in dorsally situated siphuncle, and frequent

PLATE 222

[Figures are x1 unless otherwise indicated.]

1, 2. Trocholites ammonius [Pal N Y 1]. Exterior and section. **3. Centrocyrtoceras subannulatum** [DUB, JSL 27]. Lateral view, ventral outline on right. **4, 5. Graftonoceras graftonense** [DUB, JSL 21]. Ventral and lateral views of type. **6. Plectoceras jason** (x0.5) (CGS, Pal Fos 3]. **7–9. Bickmorites bickmoreanum** (x0.25) [DUB, JSL 21]. Cross sections and dorsoventral sections, and a lateral view of a complete specimen. **10. Plectoceras undatum** (x0.5) [Pal N Y 1]. A nearly complete specimen embedded in the rock. **11, 12. Centrocyrtoceras percinctum** [DUB, JSL 27]. Lateral views (x1, x1.5). **13. Lechritrochoceras desplainense** [N Y St Mus, B 20]. Lateral view. **14. Halloceras undulatum** (x0.5) [Pal N Y 5]. **15–18. Ryticeras** spp. [Pal N Y 5]. **15. R. jason. 16–18. R. trivolve** (x0.5). Lateral and ventral views of one specimen, apertural view of another.



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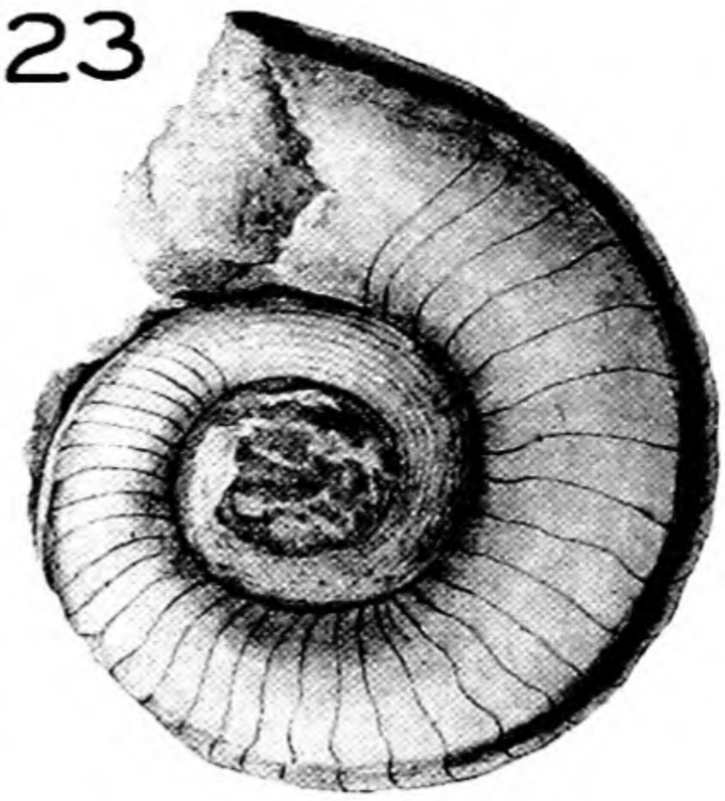

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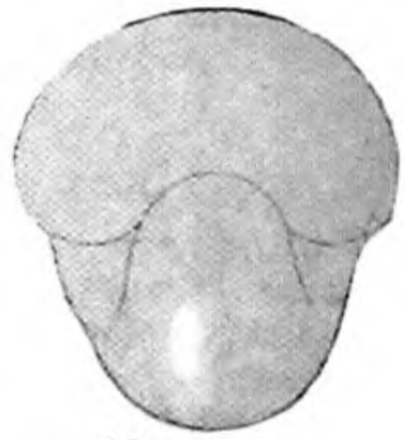

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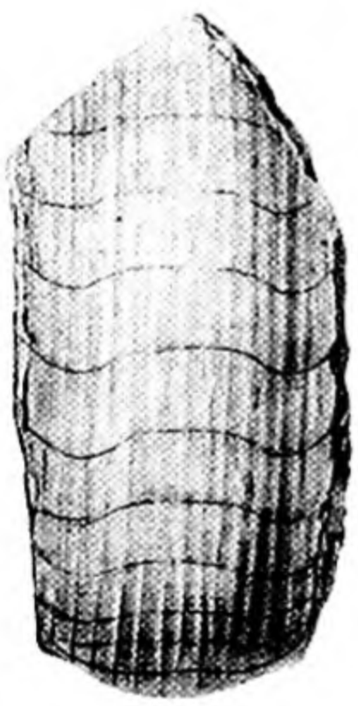

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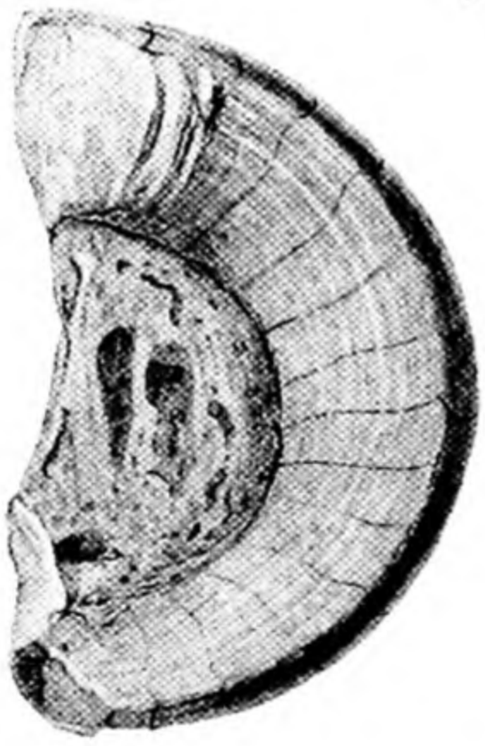

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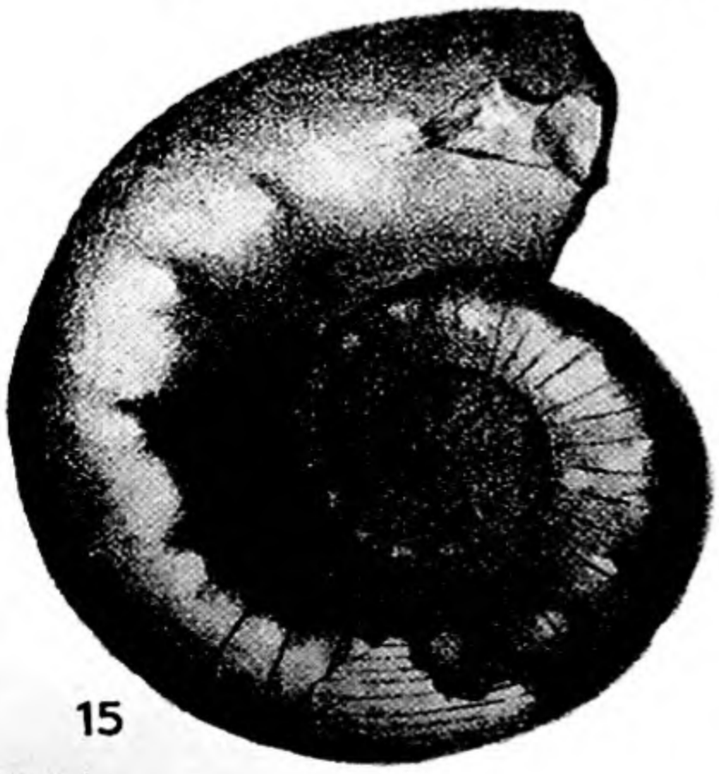

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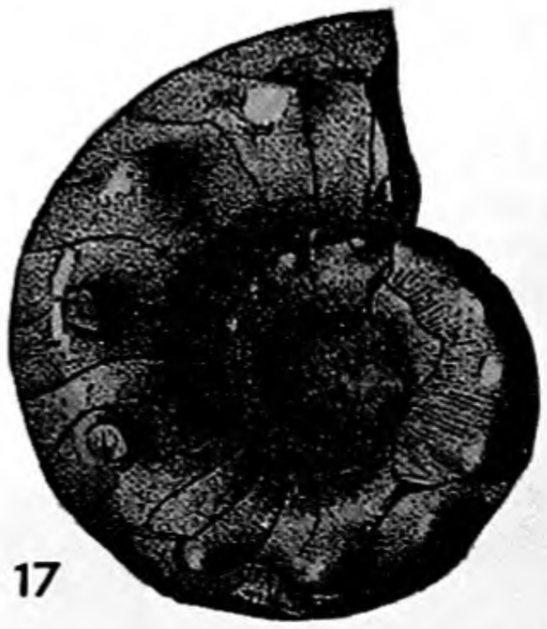

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tetragonal section of whorls. **L. Ord.** (Que.; Vt., N. Y.).

S. eatoni (Whitfield) (**221**—11). Externally like *Tarphyceras seelyi*, but smaller and with shallower septa, deeper impressed zone and dorsad siphuncle. **Canadian:** Vt. (Ft. Cassin), N. Y. (Valcour).

BARRANDEOCERAS Hyatt 1884

(**Nautilus natator* Billings). Conch coiled; volutions touching lightly, without dorsal impressed zone, or free locally; cross-section compressed laterally; sutures curve downward laterally; siphuncle slightly ventrad of conch center; segments cylindrical. **L. Ord.** (Canada; N. Y.).

***B. natator** (Billings) (**221**—13). **Chazyan:** Mingan Islands, Que. (Mingan); N. Y. (Valcour).

TROCHOLITES Conrad 1838

(**T. ammonius*). Conchs nautiloid, volutions touching as far as aperture; dorsal contact zone impressed, impression wide but shallow; transverse section reniform; sutures with distinct lateral lobes and large ventral saddles; siphuncle near or touching dorsal conch wall. **Ord.** (Que., Ont.; Vt., N. Y., Pa., Ohio, Ky.).

***T. ammonius** Conrad (**222**—1, 2). **Trenton:** Ont.; N. Y., Pa., Ky.

GRAFTONOCERAS Foerste 1925

(**Lituites graftonensis* Meek and Worthen). Shell nautiliconic; whorls with reniform cross-section, each slightly overlapping ventrolateral side of preceding; surface bearing transverse ribs which curve backward along their entire length, but curvature is increased greatly along ventrolateral parts of conch, hyponomic sinus being deeply V-shaped. **Sil.**

***G. graftonense** (M and W) (**222**—4, 5). **Niagaran:** Ont. (Guelph); Ohio (Cedarville), Ind., Wis. (Waukesha?), Ill. (Racine).

PLECTOCERAS Hyatt 1883

(**Nautilus jason* Billings). Conchs enlarging fairly rapidly, at least in youth; umbilical perforation large; apical end not touching dorsal wall of following volution; ventral side depressed convex or flattened; lateral sides more strongly convex, dorsal flattened where touching preceding volution, though convex where free; siphuncle near ventral side of conch; segments curved lengthwise, cylindrical, not enlarging within camerae; surface strongly costate, costae curving downward in ventrad direction laterally; coarse transverse striae parallel to costae. **Ord.** (Labrador; Que.; Great Slave Lake; Ont.; N. Y., Wis., Ill., Minn., Tenn.)–**Sil.** (Ind.).

***P. jason** (Billings) (**222**—6). **Chazyan:** Que. (Mingan); N. Y. (Crown Point).

P. undatum (Emmons) (**222**—10). **Black River:** Ont.; N. Y. **P. undatum occidentale** (Hall). **Black River** (Platteville): Wis., Ill., Minn.

CENTROCYRTOCERAS Foerste 1926

(**Cyrtoceras annulatum* Hall). Conchs small, strongly curved, circular in transverse section; sutures directly transverse; siphuncle slightly ventrad of conch center, segments nearly cylindrical; shell surface distinctly annulated, annulations directly transverse or curved downward slightly along median part of lateral side; also raised lines parallel to annulations. **L.** and **M. Ord.** (Ont.; N. Y., Tenn., Ia.).

C. percinctum Foerste (**222**—11, 12). **Chazyan:** Tenn. (Murfreesboro)

***C. subannulatum** (Orbigny) (= **Cyrtoceras annulatum** Hall) (**222**—3). **M. Ord.:** Ont. (Black River); N. Y. (Trenton).

BICKMORITES Foerste 1925

(**Lituites bickmoreanus* Whitfield). Gyroceracones with strongly marked transverse riblike annulations, which curve strongly downward ventrally; sutures have broad, but very shallow, lateral lobes and there may be ventral lobes, with intermediate ventrolateral saddles; siphuncle slightly ventrad of conch center; striae parallel to annulations; conch somewhat compressed laterally. **M. Sil.** (Que.; ?Pa., Ind., Ill.).

***B. bickmoreanum** (Whitfield) (**222**—7–9). **Niagaran:** Ind. (Liston Creek).

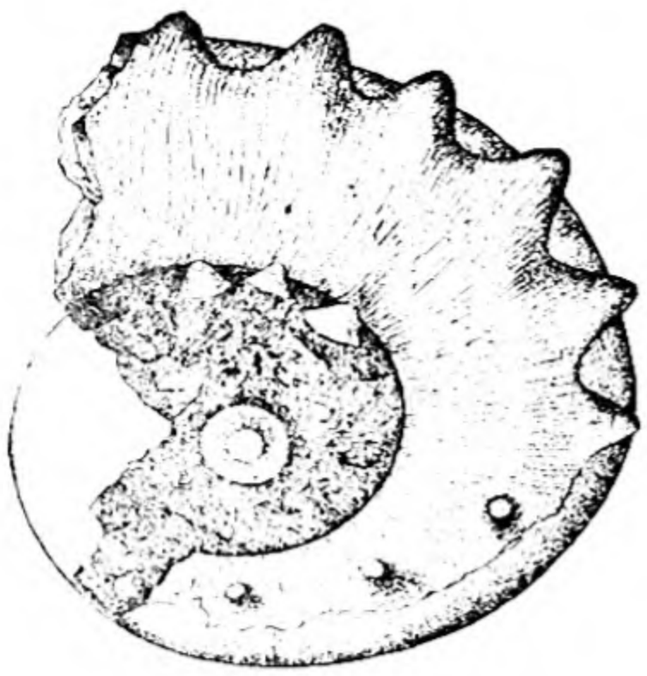
LECHRITROCHOCERAS Foerste 1930

(**Trochoceras desplainense* McChesney). Costate trochoceroids with apical end shifted laterally from plane of symmetry, but not beyond plane bounding adjacent lateral side of last volution; adjacent parts of volutions touching, except along upper part of living chamber, which is free; shallow impressed zone where apical part of conch touches dorsolateral shoulder of last volution; coiling dextral; siphuncle central; surface ornamented by riblike annulations, and numerous transverse striae parallel to annulations. **M. Sil:** (widespread throughout Arctic America, Canada, and U. S. A., and formerly referred to as *Trochoceras*, a genus not represented in N. America according to Foerste (1930, 46)).

PLATE 223

[Figures are x1 unless otherwise indicated.]

1. Centroceras marcellense (x0.5) [Pal N Y 5]. **2, 3. Stroboceras trisulcatum** [Ill G S 2]. Ventral and lateral views. **4, 5. Ephippioceras ferratum** [Neb G S, B 9]. Lateral and ventral views of an adolescent shell. **6, 7. Megaglossoceras montgomeryense** (x0.5) [Neb G S, B 9]. Ventral and lateral views. **8–10. Liroceras liratum** [USGS, B 544]. Lateral, ventral, and apertural views. **11, 12. Triboloceras digonum** [Ill G S 2]. Ventral and lateral views. **13. Endolobus spectabilis** (x0.5) [N Y Ac Sc, An 5]. Lateral view of inner septate portion. **14. Tainoceras quadrangulum** [Neb G S, B 9]. Original figure of type. **15–18. Endolobus spp. 15, 16. E. coxanus** [Ill G S 5]. Lateral and apertural views. **17, 18. E. forbesianus** [Ind G S 13].



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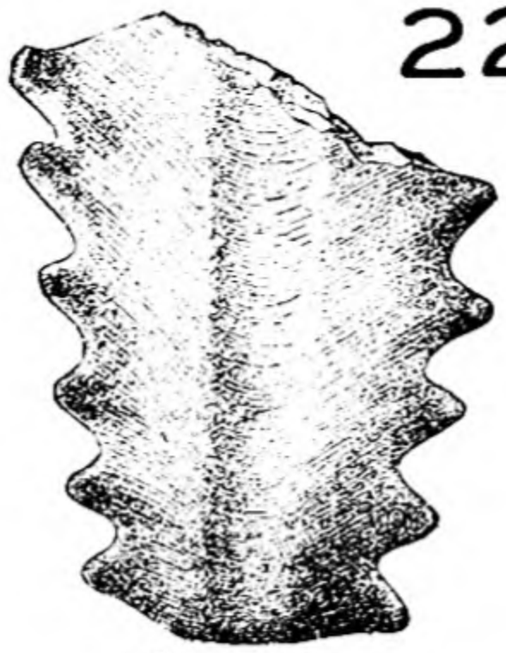

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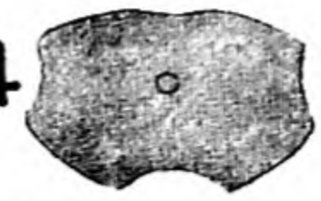

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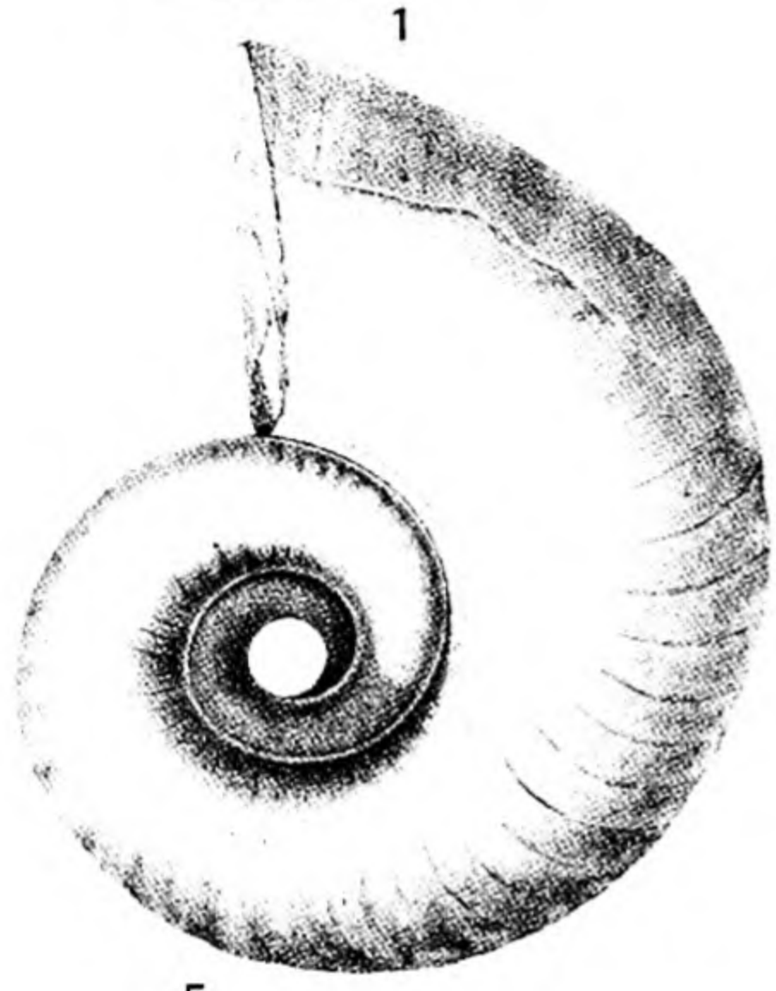

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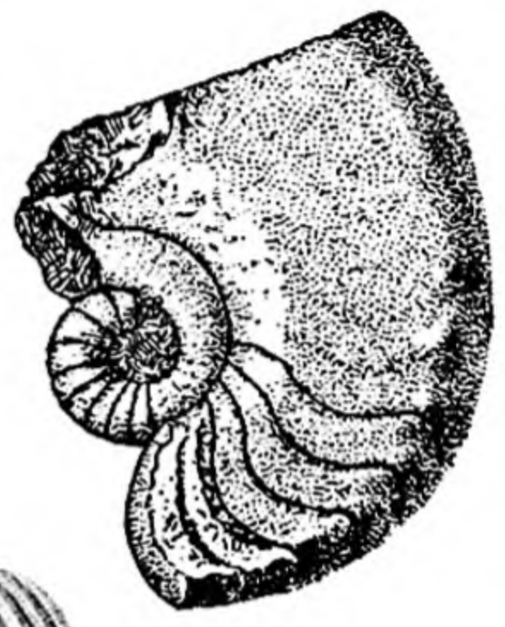

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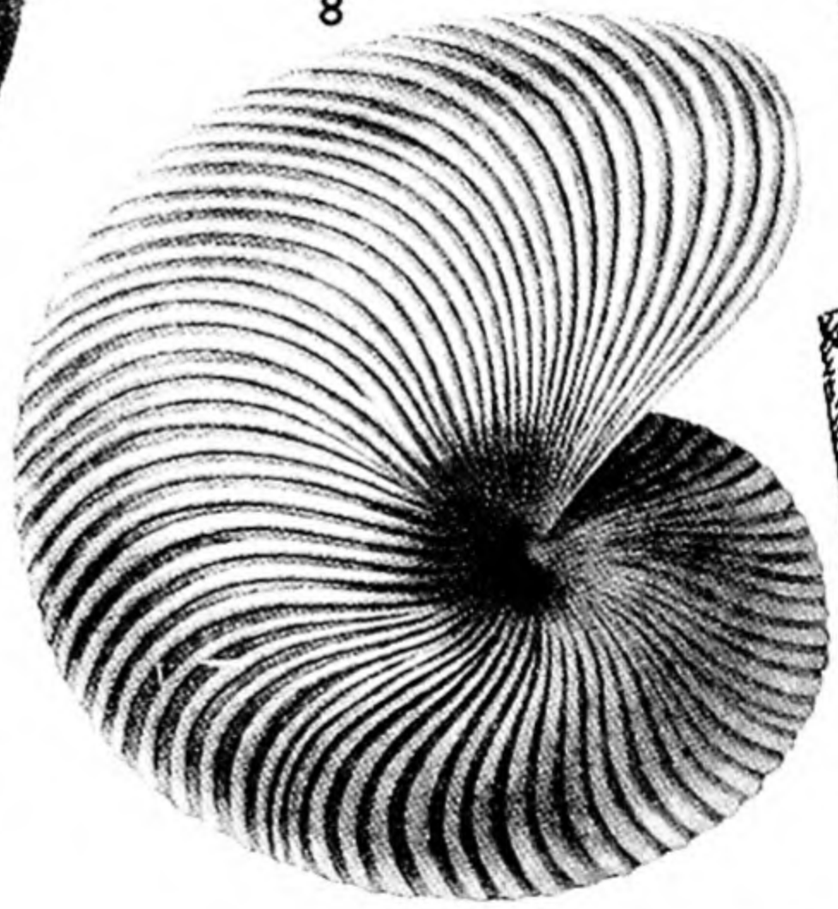

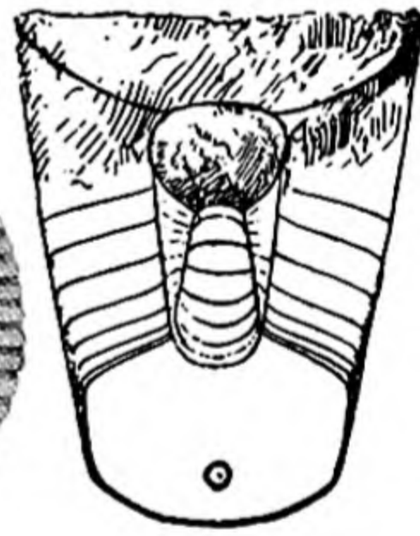

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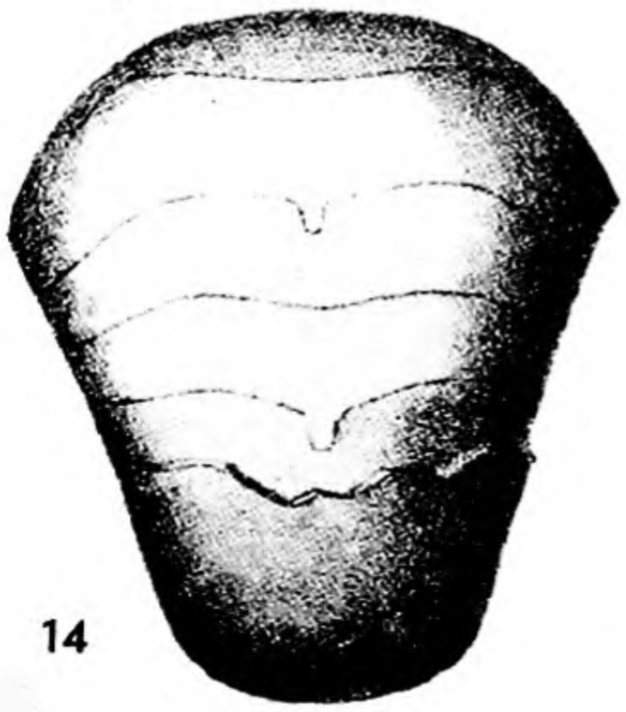

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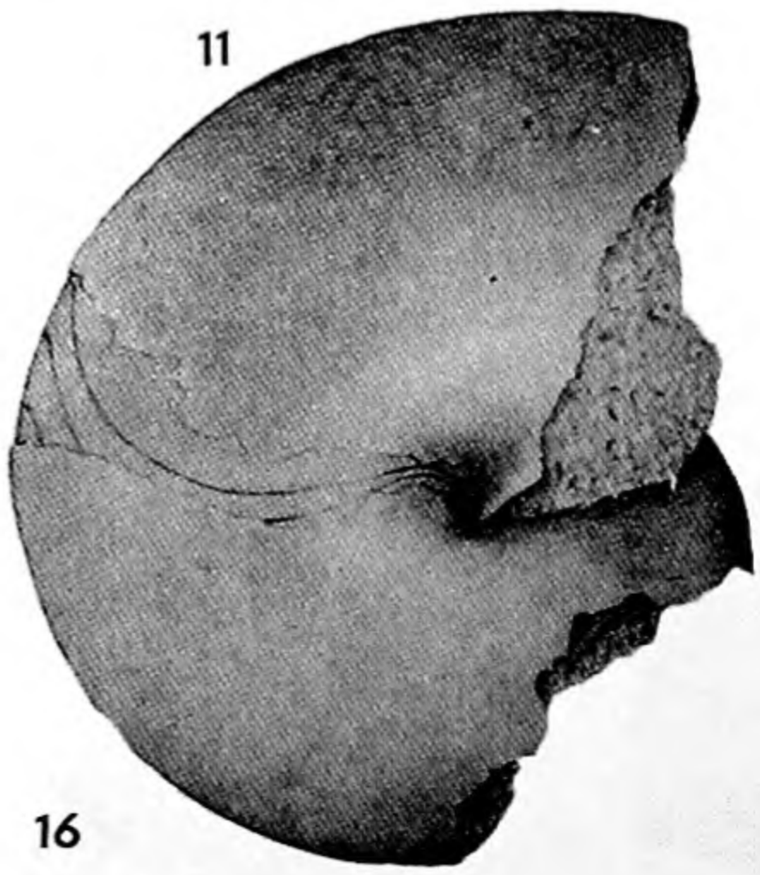

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***L. desplainense** (McChesney) (**222**—13). **Niagaran:** Ont. (Guelph); N. Y. (Shelby, Rochester), Ind. (Huntington), Wis. (Guelph), Ill.

HALLOCERAS Hyatt 1884

(**Cyrtoceras undulatus* Vanuxem). Gyroceracones of subtrigonal section; young like adults of *Zittelloceras;* venter broad, dorsum narrower and subangular; typically with row of large nodes at ventrolateral angles; siphuncle small, tubular, and near venter. **Dev.** (Mackenzie River region, Canada; N. Y., Pa.).

***H. undulatum** (Vanuxem) (**222**—14). Whorls two to three, not touching; septa distant; nodes faint. **Onondaga:** N. Y., Pa.

RYTICERAS Hyatt 1884

(= KOPHINOCERAS Hyatt 1884)

(**Cyrtoceras jason* Hall). Cyrtoceracones and gyroceracones similar to *Halloceras*, but larger and with coarser, crenulated bands often expanded into spoutlike, spinous processes, which may form coarse, longitudinal ridges; siphuncle ventral, less nummuloidal, and larger than in *Halloceras*. **Dev.** (Ont.; N. Y., Ohio, Ind., Ky., ?Ia.).

***R. jason** (Hall) (**222**—15). Robust cyrtoceracones of subcircular transverse section; septa regular; growth lamellae expanding at regular intervals into sharp, foliate and coarse spinous processes; siphuncle marginal. **Dev.:** Schoharie and Onondaga of N. Y., ?Jeffersonville of Ky.

R. trivolve (Conrad) (**222**—16–18). Conch loosely gyroceraconic; sutures with ventral lobe. **Onondaga;** Ont.; N. Y.

CENTROCERAS Hyatt 1884

(**Goniatites marcellensis* Vanuxem). Gyroceracones and nautilicones with slightly impressed zone in later stages only, with quadragonal adult but digonal young whorls; later the form is trapezoidal in outline and tuberculate as in young of *Temnocheilus*. **Dev.–Penn.** (Ont.; N. Y., Pa., Mich., Ohio, Ind., Ill., Ia.).

***C. marcellense** (Vanuxem) (**223**—1). **M. Dev.:** N. Y. and Pa. (Marcellus); possibly Genesee of latter.

STROBOCERAS Hyatt 1884

(**Gyroceras harttii* Dawson). Gyroceraconic or nautiliconic, with gibbous umbilical shoulders making dorsum wider than venter, and with two pairs of lateral revolving ridges; aperture contracted and dumb-bell shaped; siphuncle slightly ventral of center; young like *Trigonoceras*. **Miss., Penn.** (N. S.; Ohio, Ind.).

S. trisulcatum (Meek and Worthen) (**223**—2, 3). **L. Miss.:** Ohio (Waverly), Ind. (Rockford).

EPHIPPIOCERAS Hyatt 1884

(**Nautilus ferratus* Cox). Subglobose; conch nautiliconic, expanding rapidly; whorls depressed, reniform in section; umbilicus small but deep; umbilical shoulders evenly rounded and therefore indistinct; aperture with shallow ventral hyponomic sinus; surface typically smooth; sutures strongly sinuous; the broad, deep, subacute ventral saddle is distinctive; siphuncle small, subcentral, orthochoanitic; septal necks short but straight; connecting rings cylindrical. **Miss.** (Europe), **Penn.** (Ohio and Ky. to Neb. and Tex.; Europe and Great Britain).

***E. ferratum** (Cox) (**223**—4, 5). **Penn.** (Cherokee–Lansing): Ky., Mo. (Dennis, Westerville), Ark. (Atoka), Neb. (South Bend), Kan. (Westerville), Okla. (Lansing), Tex. (Cherokee–Stanton).

MEGAGLOSSOCERAS Miller, Dunbar and Condra 1933

(**Nautilus montgomeryensis* Worthen). Closely related to *Ephippioceras*, but differing in having broad, tongue-shaped ventral saddles, subacute umbilical shoulders, and somewhat differently shaped conch. **Penn.** (central U. S. A.).

***M. montgomeryense** (Worthen) (**223**—6, 7). **U. Penn.:** Ill. (McLeansboro).

LIROCERAS Teichert 1940

(= COLOCERAS Hyatt 1893)

(**Coloceras liratum* Girty). Nautiliconic; youthful shells subglobose, with whorls having reniform section; umbilicus moderately large and perforate, umbilical shoulders rounded; sutures straight and directly transverse to long axis of conch; siphuncle small, orthochoanitic, variable in position with growth; may be a synonym of STEAROCERAS Hyatt 1893 (**Endolobus gibbosus*) but siphuncular structure when elucidated will indicate true relationship of the two genera. **U. Miss.** (Chester)–**M. Perm.** (Phosphoria) in N. America (Pa., Ind., Mo., Ark., Kan., Okla., Tex.); **Miss.–M. Perm.** of Europe.

***L. liratum** (Girty) (**223**—8–10). **Penn.:** Kan. (Weston), Okla. (Boggy, Copan, Henrietta, Nellie Bly), Tex. (Graham, Jacksboro).

L. missouriense (Swallow). **Penn.:** Pa. (Vanport), Ind., Mo. (Cherokee), Ark. (Atoka).

PLATE 224

[Figures are x1 unless otherwise indicated.]

1, 2. Temnocheilus winslovi (x0.5) [Ind G S 13]. Lateral and ventral views. **3, 4. Metacoceras sangamonense** [Neb G S, B 9]. Diagrammatic cross section (slightly less than x1) and lateral view. **5, 6. Titanoceras ponderosum** (x0.25) [USGS Neb, F Rp (2)]. Lateral and ventral views. **7, 8. Pseudometacoceras sculptile** [USGS, B 544]. Ventral and lateral views. **9, 10. Domatoceras lasallense** (x0.5) [Ill G S 5]. Ventral and lateral views. **11. Cymatoceras carlottense** [CGS, Mes Fos]. **12, 13. Metacoceras cavatiforme** [Tex G S, An Rp 2]. Fragment showing internal whorls. **14, 15. Solenocheilus collectus** [Ill G S 5]. Views of two specimens. **16, 17. Stenopoceras abundum** (x0.5) [JP 10].

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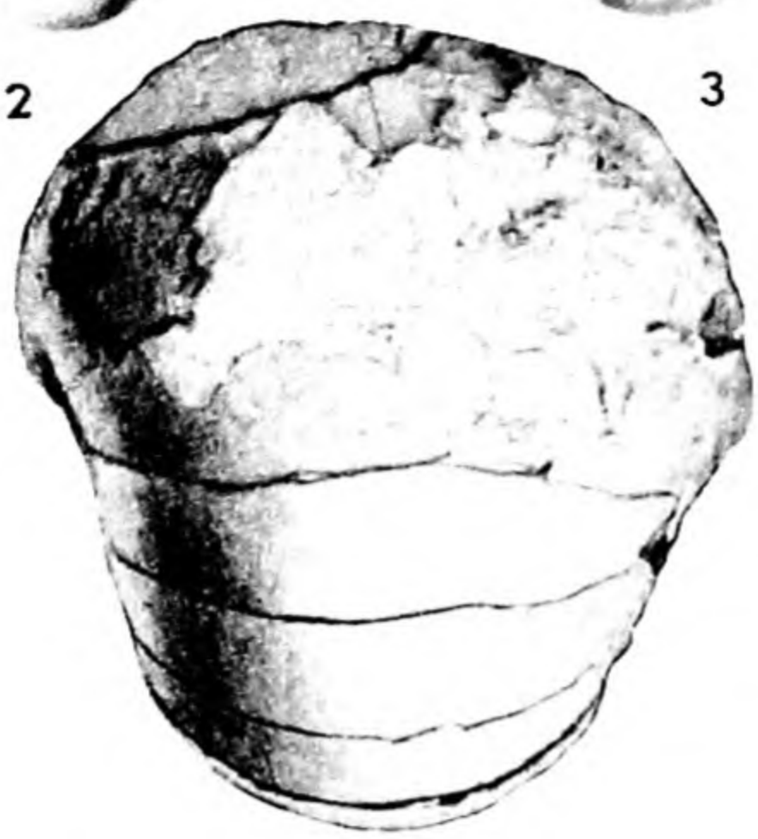

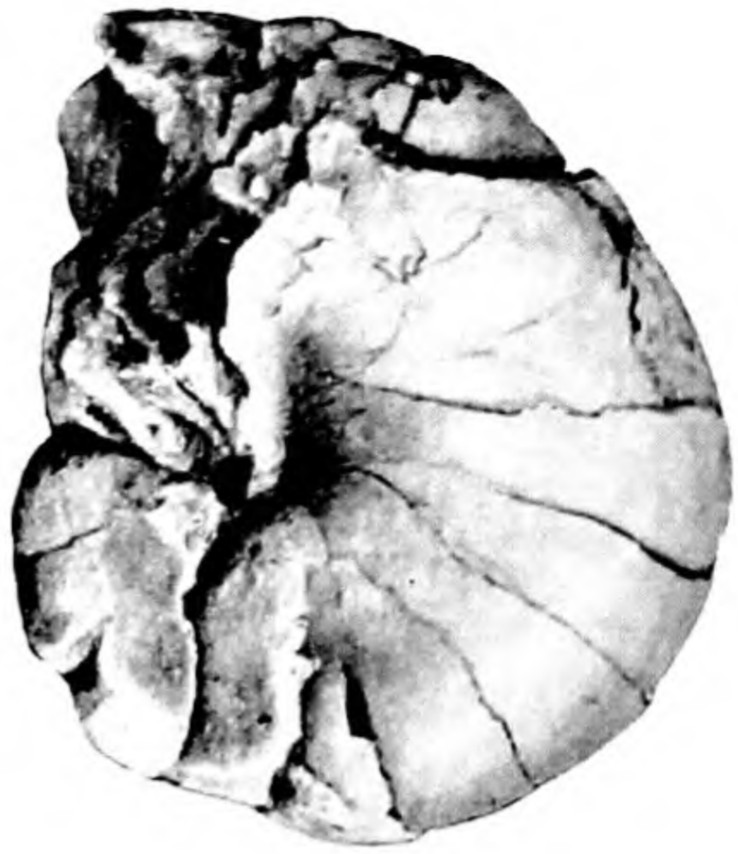

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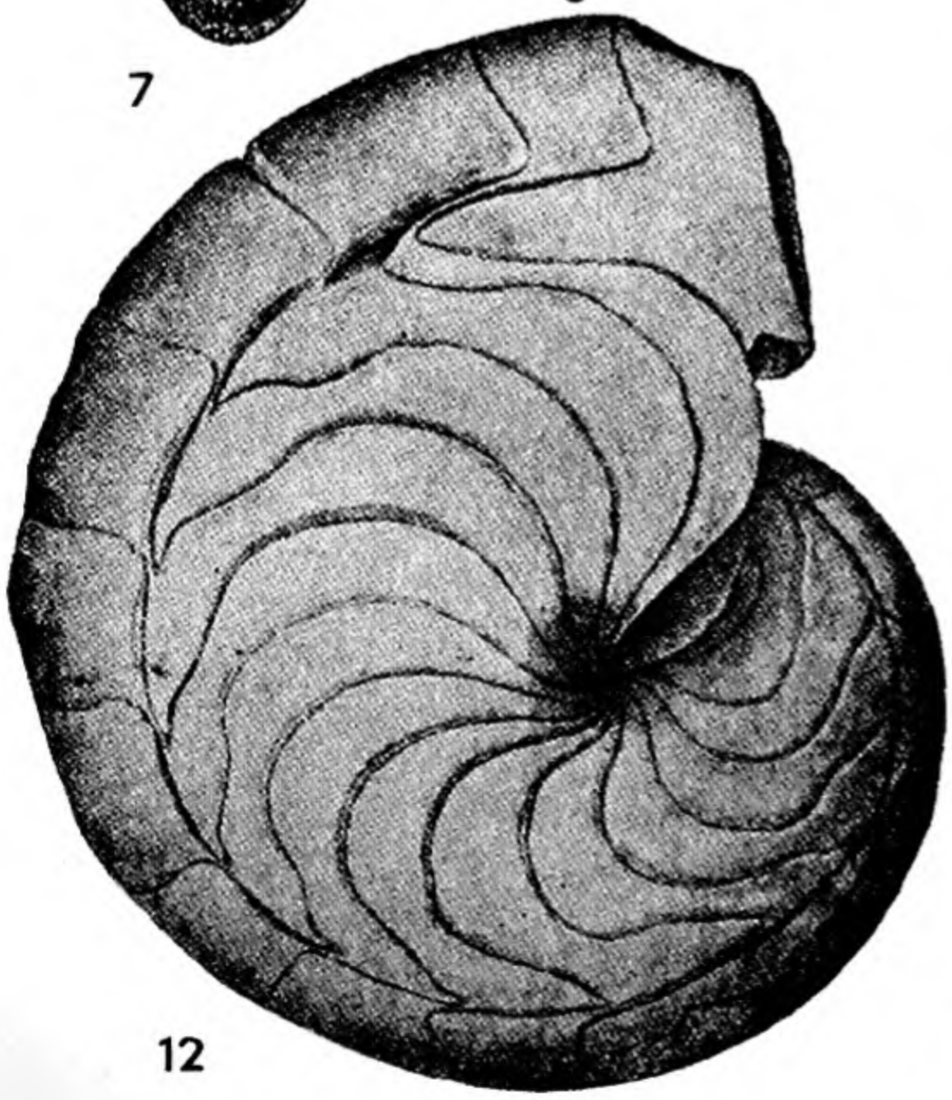

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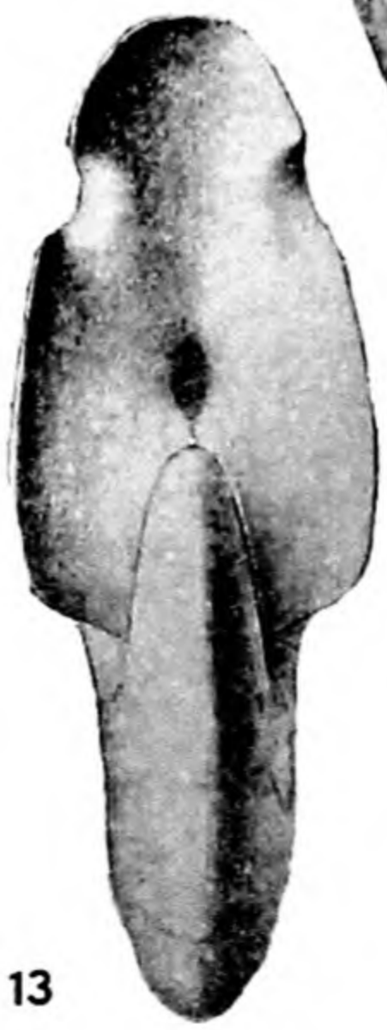

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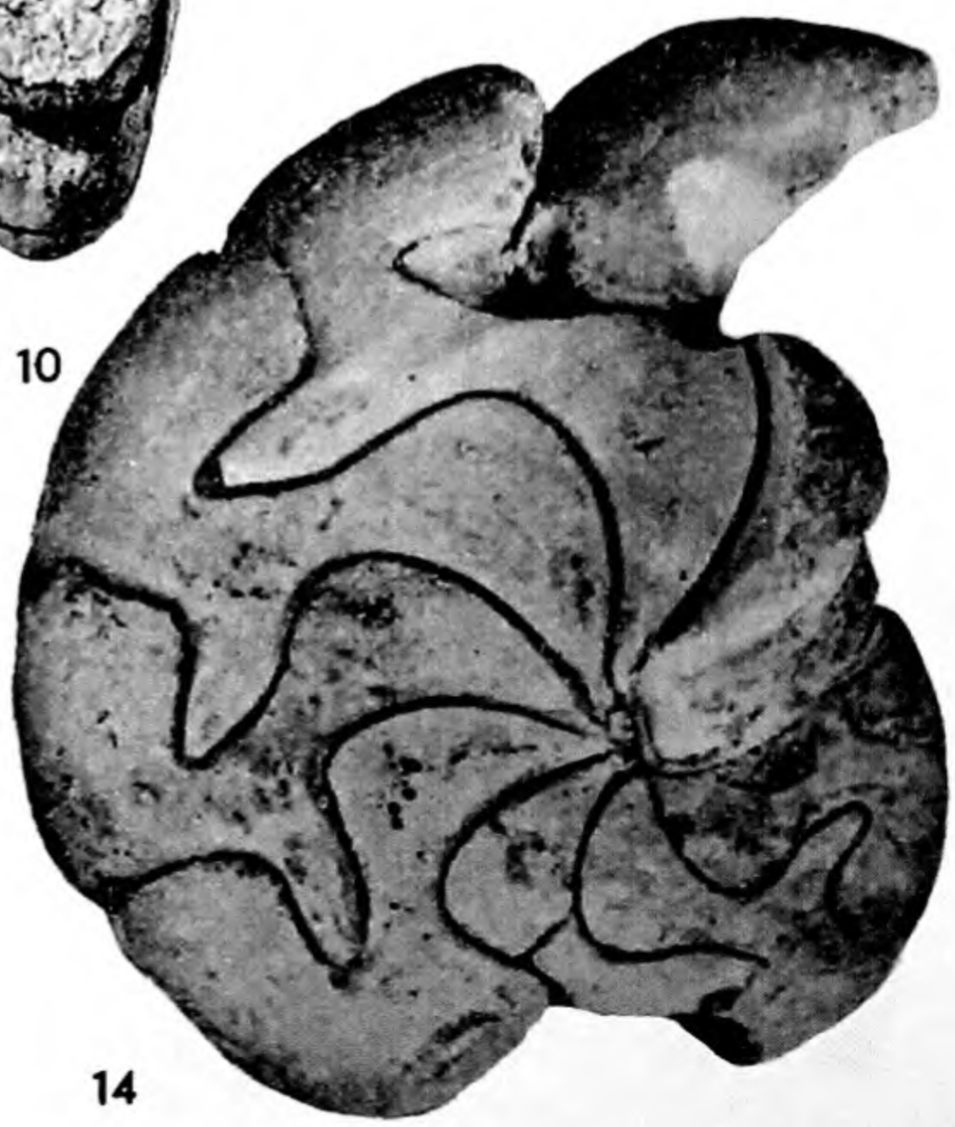

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TRIBOLOCERAS Hyatt 1884

(**Gyroceras serratum* Koninck). Gyroceracones and nautilicones; venter channeled in young shells, which are also characterized by subspinous ridges; adult volutions depressed, biangular, with gibbous dorsum and convex venter, or approximately triangular; siphuncle subcentral; sutures with broad ventral and lateral lobes, and dorsal saddles without annular lobes. **Miss.**

T. digonum (Meek and Worthen) (**223**—11, 12). **Kinderhook:** Ind. (Rockford), Ill., Mo.

TAINOCERAS Hyatt 1883

(**Nautilus quadrangulus* McChesney: Hyatt's original three figures are actually three separate species — *T. quadrangulum* (McChesney), *T. nodocarinatum* (McChesney), and *Metacoceras* sp.). Similar to *Metacoceras*, but differing in having two longitudinal rows of nodes on ventral side of conch and with sutures bearing a pair of secondary saddles on flanks of ventral lobe. **Penn., L. Perm.** (U. S. A.): **U. Carb., Perm.** (Europe); **U. Carb.** (Asia).

***T. quadrangulum** (McChesney) (**223**—14). **Penn.:** Midwestern U. S. A.

ENDOLOBUS Meek and Worthen 1865

(**Nautilus spectabilis* Meek and Worthen = *Nautilus* (*Endolobus*) *peramplus* Meek and Worthen). Nautiliconic; umbilicus broad, deep, perforate; hyponomic sinus broad, deep and tongue-shaped; lateral zones of conch with numerous prominent nodes; sutures simple, transverse, slightly sinuous; siphuncle small, subcentral, orthochoanitic. **U. Miss.–U. Perm.,** but most abundant in **Penn.** (Ohio, Ind., Ill., Mo., Ark., Kan., Tex., N. Mex.).

***E. spectabilis** (M and W) (**223**—13). **Chester:** Ohio (Maxville), Ill., Mo.

E. coxanus (Meek and Worthen) (**223**—15, 16). **Miss.** (St. Louis): Ind., Ill.; **Penn.:** Tex.

E. forbesianus (McChesney) (**223**—17, 18). **Penn.:** Ohio, Ind., Ill., Mo., Tex.

TEMNOCHEILUS McCoy 1844

(**Nautilus* (*Temnocheilus*) *coronatus* McCoy). Very similar to *Metacoceras*, but conch is strongly depressed, lateral sides of conch typically converge dorsally, and ventrolateral nodes are more or less confluent. **Penn.** (widespread throughout U. S. A.). **Perm.**

T. winslovi (Meek and Worthen) (**224**—1, 2). **Penn.:** Ind., Ill. Mo.; **Perm.:** Tex.

TITANOCERAS Hyatt 1884

(**Nautilus ponderosus* [White] Meek). Distinguished from most other similar genera (*Endolobus*, *Metacoceras*, etc.) by shape and ornamentation of conch, and course of sutures alone. **Penn., Perm.** (Ill., Ia., Mo., Neb., N. Mex.).

***T. ponderosum** (Meek) (**224**—5, 6). **U. Penn.:** Ill., Ia., Mo., Neb.

METACOCERAS Hyatt 1883

(**Nautilus* (*Discus*) *sangamonensis* Meek and Worthen). Subdiscoidal; conch greatly flattened ventrally, laterally and dorsolaterally and only slightly impressed dorsally; umbilical shoulders typically narrowly rounded; umbilicus large and perforate, umbilical wall straight but not steep; aperture with broad, rounded, ventral hyponomic sinus; conch surface marked with growth lines and prominent rounded ventrolateral nodes or short spines; each suture forms a broad shallow rounded lobe on ventral, lateral, and dorsal sides of conch, and these are separated by subacute saddles; siphuncle small, subcentral and nearer venter, orthochoanitic; septal necks short but straight; connecting rings not expanded: siphuncular segments cylindrical. **Penn., Perm.**

This is a "form genus" including over 30 species and varieties from the **Penn.** and **L. Perm.,** some of which are probably not congeneric. American species, ranging from Pottsville into Fort Riley of Big Blue. are reported from Ohio, Ill., Mo., Kan., Okla., and Tex. Also Great Britain; Russia; Sumatra.

***M. sangamonense** (M and W) (**224**—3, 4). Volutions subquadrate; sides strongly concave; ventrolateral angulation with elongated nodes; venter rounded; siphuncle ventrad of center; impressed zone moderate. **Penn.:** Ill., Mo., Kan.

M. cavatiforme Hyatt (**224**—12, 13). Whorls broader and more quadrate than preceding; angle nodose; venter broadly convex; sides flat; sutures with strong lateral lobe. **U. Penn.:** Mo.

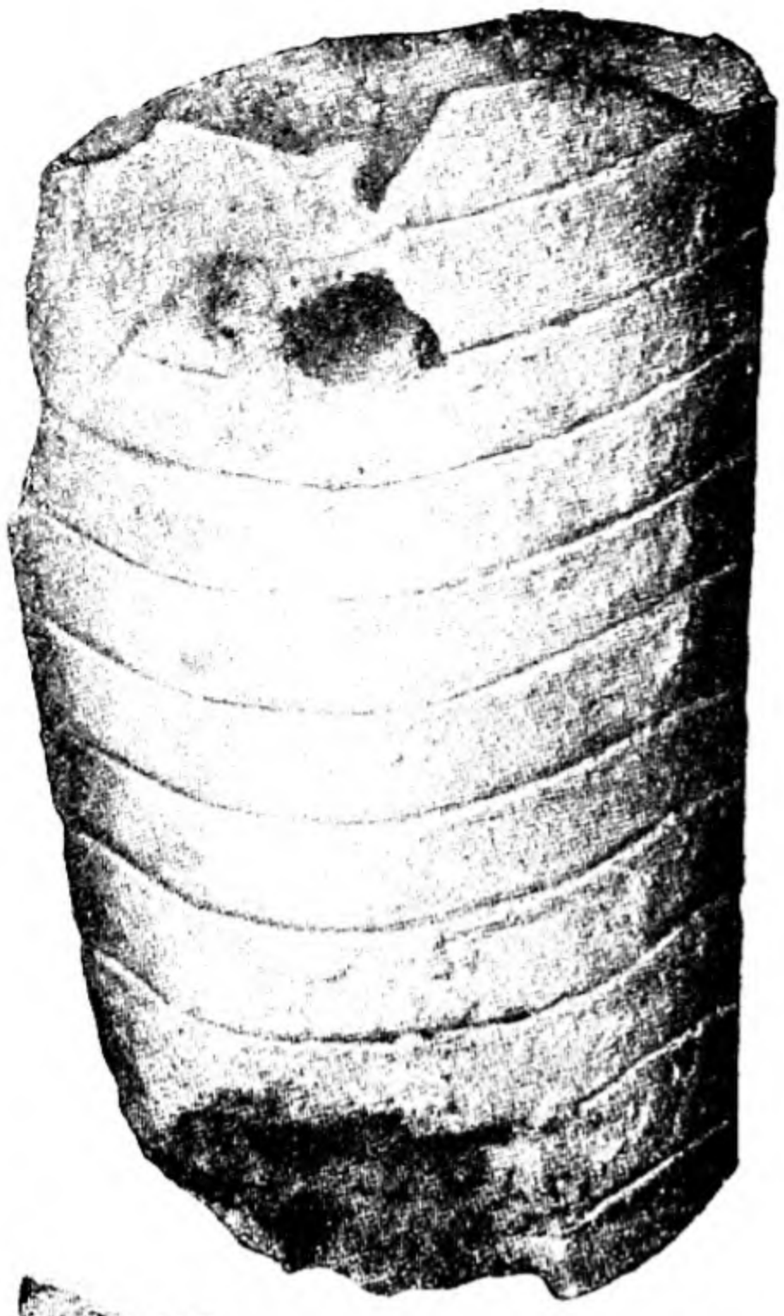
PSEUDOMETACOCERAS Miller, Dunbar and Condra 1933

(**Metacoceras sculptile* Girty). Conch subdiscoidal, tarphyceraconic, consisting of a few gradually expanding volutions; umbilicus perforate and wide; growth lines prominent on adult shell, their course indicating a very prominent hyponomic sinus; sutures with broad, shallow, rounded ventral, lateral, and dorsal lobes with subacute saddles at the ventrolateral angles and at umbilical seams; siphuncle small, nearly central and orthochoanitic; septal necks short and connecting rings subcylindrical. **Penn.**

***P. sculptile** (Girty) (**224**—7 8). **Penn.:** Md. (Ames), Ky. (Kendrick), Neb. (Plattsmouth, Irvine Creek), Okla. (Wewoka), Tex. (Graham).

PLATE 225

1–5. Eutrephoceras spp. 1–3. E. dekayi (x0.5) [USGS Ter 9]. A large specimen, and two views of a young individual. **4, 5. E. alcesense** (x1) [USGS, PP 151]. **6. Cimomia subrecta** (x0.5) [JP 7]. **7–9. Hercoglossa ulrichi** (x0.25) [USGS, B 4]. Three views of a nearly complete specimen. **10–13. Aturia spp. 10, 11. A. alabamensis** (x1.5) [JP 12]. **12, 13. A. vanuxemi** (x0.5) [Pal N J 2]. **14. Aturoidea paucifex** [Pal N J 4]. Lateral view of type specimen (x0.3).



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DOMATOCERAS Hyatt 1891

(**D. umbilicatum*). Nautilicones with slightly impressed zone in adult, biangular in young; volutions tetragonal in section; surface smooth; sutures with marked umbilical saddles; siphuncle ventrad of center. **Penn., L. Perm.** (Ill., Mo., Kan., Colo., Tex., N. Mex.; Russia; Himalayas; Timor).

D. lasallense (Meek and Worthen) (**224**—9, 10). **Penn.:** Ill. (McLeansboro), Ia.

STENOPOCERAS Hyatt 1893

(**Pharcoceras dumbli*). Conch discoidal, nautiliconic; venter concave in adult part of conch; sutures gently sinuous. **Penn., Perm.** (genus known from Penn. of Neb.; Fort Riley (L. Perm.) of Kan.; U. Penn. of N. Mex.; and U. Carb. of central European Russia).

S. abundum Miller and Thomas (**224**—16, 17). **Casper:** Wyo.

SOLENOCHILUS Meek and Worthen 1870

(**Nautilus* (*Cryptoceras*) *springeri* White and St. John). Nautilicones with smooth surface; siphuncle small, in contact or nearly so with venter; lip auriculate near dorsal angles; differs from related genera in shape of conch, absence of nodes and spines, and in ventral position of siphuncle. **L. Miss.–L. Perm.** (Ind., Ill., Mo., Kan., Tex.; Europe).

S. collectus Meek and Worthen (**224**—14, 15). Venter gently rounded; umbilicus small but deep. **Miss.** (St. Louis): Ind., Ill.; **Penn.:** Tex.

CYMATOCERAS Hyatt 1884

(= NAUTILUS in part of authors)

(**Nautilus pseudo-elegans* Orbigny). Strongly involute nautilicones with strong transverse costae extending across entire shell; sides gibbous, becoming compressed in adults of some species; sutures with ventral saddles; shallow lateral and dorsal lobes; siphuncle usually slightly dorsad of center; young conchs noncostate. **Cret.** (Mont., Tex.; B. C.).

C. carlottense Whiteaves (**224**—11). **Queen Charlotte:** B. C.

EUTREPHOCERAS Hyatt 1894

(**Nautilus dekayi* Morton). Involute, subglobose nautiloids; volution nephritic in transverse section throughout life, changing but little; umbilicus closed; siphuncle usually dorsad of whorl center; shells usually smooth except for fine longitudinal lines on venter and growth lines parallel to aperture; sutures nearly straight, having shallow elements — ventral lobe, broad ventrolateral saddle, lateral lobe, second lateral saddle, umbilical lobe, and broad, obtusely pointed dorsal lobe. **Cret., Eoc.** (widespread throughout U. S. A.).

***E. dekayi** (Morton) (**225**—1–3). Ornamentation of young is retained in var. **mortonense. Ripley:** Atlantic and Gulf Coast regions; Minn., Ark.; **Montanan** (characteristic of Pierre):, N. and S. Dak., Neb., Mont., N. Mex.; Alta.

E. alcesense Reeside (**225**—4, 5). **U. Cret.:** Mont. (Eagle, Telegraph Creek, Cody), Wyo. (Telegraph Creek, Cody, Steele), Utah (Mancos), N. Mex. (Mancos, Mesaverde).

HERCOGLOSSA Conrad 1866

(= NAUTILUS in part of authors)

(**Nautilus orbiculatus* Tuomey). Highly involute nautilicones with deeply lobed sutures and broad undivided ventral saddle; siphuncle small, central or dorsad of center. **Trias.–Tert.** (Atlantic, Gulf and Pacific coastal regions).

H. ulrichi (White) (**225**—7–9). **Midway:** Gulf States (Ala., Tex., etc.).

ATURIA Bronn 1825

(**Nautilus aturi* Basterot). Differs from *Hercoglossa* in having large siphuncle close to dorsum from an early stage onward, the funnels of which are very long and large. (Schenck (1931, 436) states that "*Aturia* is a tachygenic genus, and the organism emerged from the egg capsule with adult characteristics; it then lived a vagile benthonic life in the sublittoral zone of the sea.") **U. Cret.–Plioc.** (Atlantic, Gulf and Pacific coastal regions; northern Mexico).

A. vanuxemi Conrad (**225**—12, 13). **Eoc.:** N. J. (Shark River).

A. alabamensis (Morton) (**225**—10, 11). **Jackson:** N. C. (Castle Hayne), Fla. (Ocala), Ala. (Ocala, Claiborne), Miss. (Moodys); Nuevo León and Tamaulipas, Mexico.

ATUROIDEA Vredenburg 1925

(= PARATURIA Spath 1927)

(**Nautilus parkinsoni* Edwards). Closely related to *Hercoglossa* and *Aturia* and more or less intermediate between them. **U. Cret., Eoc.** (Atlantic and Pacific coastal regions; England; northern Africa; India).

A. paucifex (Cope) (**225**—14). **Eoc.:** N. J. (Hornerstown).

CIMOMIA Conrad 1866

(**Nautilus burtini* Galeotti). Nautiliconic; um-

PLATE 226

[Figures are x1 unless otherwise indicated.]

1–3. Actinoceras spp. [ĐUB, JSL 25]. **1, 2. A. bigsbyi.** Ventral view, and dorsoventral section with ventral outline on right. **3. A. beloitense.** Ventral view of a nearly complete specimen showing adapertural tapering of living chamber (x0.2). **4, 5. Leurorthoceras hansenense.** Ventral view of a nearly complete specimen showing adapertural tapering of living chamber (x0.5) [DUB, JSL 19]. Ventral side, and dorsoventral section (siphuncle actually enlarges upward). **6. Dolorthoceras exile** [Pal Am 2 (10)]. Phragmocone and base of living chamber. **7. Armenoceras hearsti** [DUB, JSL 22]. Dorsoventral section through siphuncle (x0.5). **8, 9. Kochoceras cuneiforme** [Troedsson, Jub Nord om Gronland, B 71]. Holotype showing breviconic shape, dorsal side of siphuncle with actinoceroid structure; cross section. **10, 11. Bradfordoceras** spp. [B Am Pal 22]. **10. B. transversum. 11. B. consortale. 12, 13. Elrodoceras indianense** (x0.5) [DUB, JSL 20]. Ventral view showing surface, and opposite side showing camerae. **14, 15. Mooreoceras normale** (x2) [Neb G S, B 9]. Lateral view of holotype, and dorsoventral section of adapical camerae.

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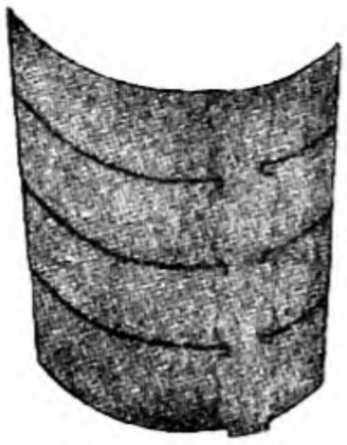

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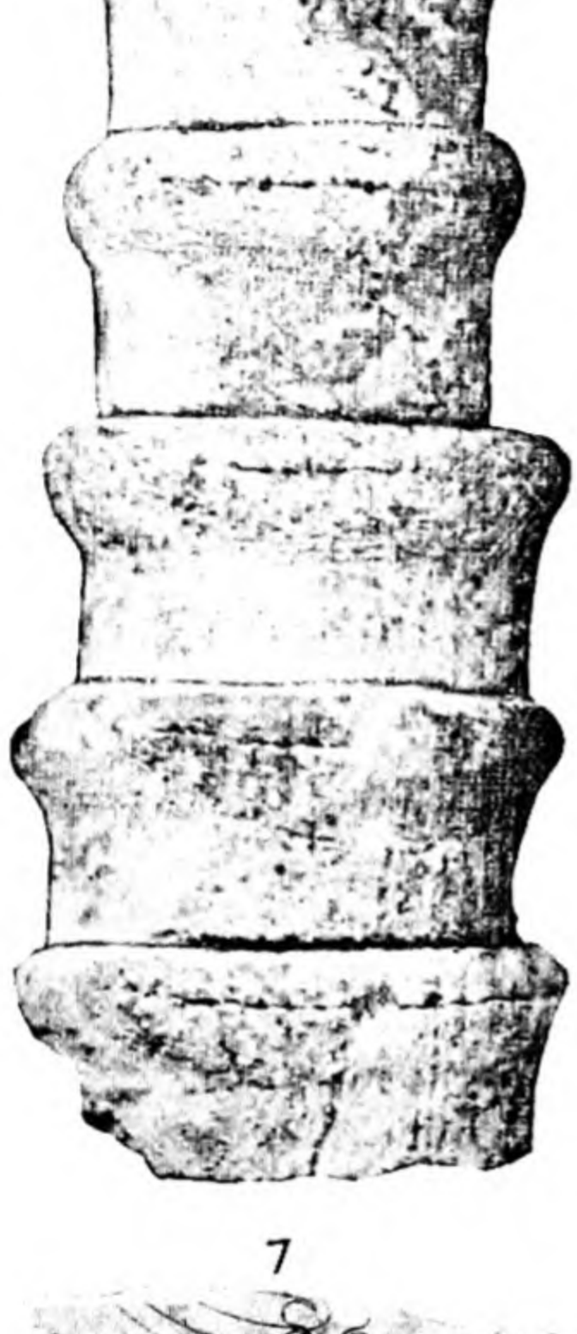

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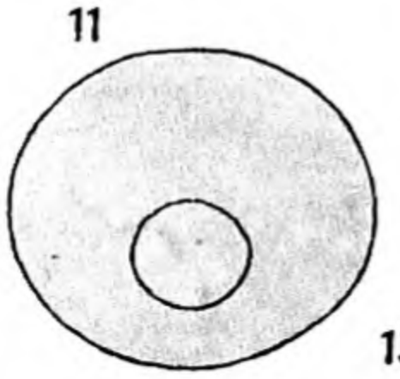

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bilicus small, umbilical shoulders low and broadly rounded; conch surface smooth; septa numerous and sutures somewhat sinuous; siphuncle small, circular in section, orthochoanitic. **Tert.** (Atlantic and Gulf Coast region).

C. subrecta Miller and Thompson (**225**—6). **Midway:** Miss.

Order Cyrtochoanites. Conchs orthoconic to nautiloconic, commonly ornamented with ribs, annulations and nodes; sutures very simple; septal necks generally short and commonly bent outward or crumpled; siphuncle simple, nummuloidal or complex, and order includes all nautiloids with beaded siphuncles; apertures may be restricted. **Ord.–Penn.**

ACTINOCERAS Bronn 1837

(**A. bigsbyi*). Actinoceroid orthocones in which siphuncles usually are large, compared with conch diameter, and siphuncular segments low, broad, and nummuloidal while intervening septal necks are relatively long; siphuncular interior more or less filled with calcareous deposits which first envelop inner surface of septal necks, then continue in growth until only an irregular tubelike space along central part of siphuncle remains free from deposition during life, though usually filled with matrix in fossils; this type of calcareous deposit is not only characteristic of *Actinoceras* but of all genera usually grouped as actinoceroids; *Actinoceras* is a "form genus." **M. Ord.** (widespread throughout Arctic America, Canada, and U. S. A.).

***A. bigsbyi** Bronn (**226**—1, 2). **Black River:** Arctic America; Ont.; N. Y., Ky. (Tyrone), Tenn., Wis. and Minn. (Platteville); Man. (Red River).

A. beloitense Whitfield (**226**—3). **Black River:** Ont.; Tenn. (Tyrone), Wis. (Platteville).

LEURORTHOCERAS Foerste 1921

(**L. hanseni*). Evidently closely related to typical *Actinoceras;* dorsoventrally depressed, with ventral side distinctly flattened; sutures nearly horizontal dorsally but curving distinctly downward ventrally; siphuncle ventrad, but separated from conch wall; segments depressed globular to vertically elongated; septal necks long. **Ord.** (Greenland; Arctic America; Mich., Tenn.).

***L. hanseni** Foerste (**226**—4, 5). **M. Ord.:** Greenland; Arctic America

KOCHOCERAS Troedsson 1926

(**K. cuneiforme*). Differs from *Actinoceras* chiefly in distinct flattening of ventral side; tightly depressed ventral annulations; connecting siphuncular rings in broad contact with this side; siphuncle as whole depressed dorsoventrally, this depression increasing toward upper part of conch. **Ord.** (Greenland; Arctic America; Hudson Bay and Great Slave Lake regions; Man.; Wyo.).

***K. cuneiforme** Troedsson (**226**—8, 5). **Ord.:** Greenland (Cape Calhoun).

ARMENOCERAS Foerste 1924

(**Actinoceras hearsti* Parks). Conchs differing from typical *Actinoceras* chiefly in absence of distant septal necks, both overlying and underlying rings being adnate to intermediate septa for considerable width in area immediately surrounding passage of siphuncle through septa; in those species in which underlying rings are not adnate to septa immediately above, they meet inner margin of these septa at a very acute angle, without a distinct septal neck intervening. **Ord., Sil.** (widely distributed over the northern half of N. America (Greenland, Arctic America, Anticosti, Que., Ont., Man.), throughout eastern U. S. A. (N. Y., Mich., Ind., Tenn., Ia.), and in Europe, Korea, Manchuria, and Northern China). The genus is characteristically **M.** and **U. Ord.**

***A. hearsti** (Parks) (**226**—7). **Ord.:** Ont. (Severn River).

ELRODOCERAS Foerste 1924

(**Cyrtoceras indianense* Miller). Conchs actinoceroid, cyrtoceraconic at base, but straight farther up; siphuncle ventrad of conch center; segments barrel-shaped; septal necks very short and with abruptly recurved brim; surface striae curve downward slightly along ventral side of conch, thus locating hyponomic sinus. **M. Sil.** (Ohio, Ind., Wis., Ill.).

***E. indianense** (Miller) (**226**—12, 13). **Niagaran:** Ind. (Laurel).

BRADFORDOCERAS Flower and Caster 1935

(**B. transversum*). Conch long, straight, gradually expanded orad, but with constriction near mature aperture; sutures oblique, descending orad on dorsum, slightly sinuous at sides, sometimes with definite lobes and saddles; siphuncle slightly eccentric, about midway between conch center and venter, cyrtochoanitic, and lined with continuous lamellar deposits; camerae with deposits; pseudosepta present. **U. Dev.** (N. Y., Md., Pa., Ia.; Man.).

***B. transversum** F and C (**226**—10). **U. Dev.:** Pa. (Venango, Salamanca).

PLATE 227

[Figures are x1 unless otherwise indicated.]

1. Pseudorthoceras knoxense [Neb G S, B 9]. Large fragmental phragmocone with lower portion sectioned. **2, 3. Euloxoceras greeni** [Neb G S, B 9]. Diagrammatic dorsoventral section (x4) and the holotype (x2). **4, 7, 8. Huronia** spp. [U Mich Mus G, Contr 2]. **4. H. bigsbyi.** Lateral and ventral views of siphuncle. **5, 6. Huronintermedia.** View of siphuncle (x0.3). **7. H. vertebralis.** A somewhat crushed siphuncle. **8. H. bigsbyi.** A fragmental siphuncle. **5, 6. Huronielia inflecta** (x0.3) [U Mich Mus G, Contr 2]. Lateral and ventral views of siphuncle. **9, 10. Sactoceras josephianum** [DUB, JSL 27]. Lateral view; another specimen cut to expose siphuncle. **11, 12. Lambeoceras** spp. **11. L. lambei** [DUB, JSL 24]. Ventral view with upper part showing siphuncle (x0.25). **12. L. confertum** [DUB, JSL 30]. Ventral view (x0.5). **13, 14. Ormoceras allumettense** [DUB, JSL 27]. Cross section, and ventral view of a weathered specimen. **15. Gonioceras anceps** [Pal N Y 1]. Longitudinal section showing small part of siphuncle (x0.5).

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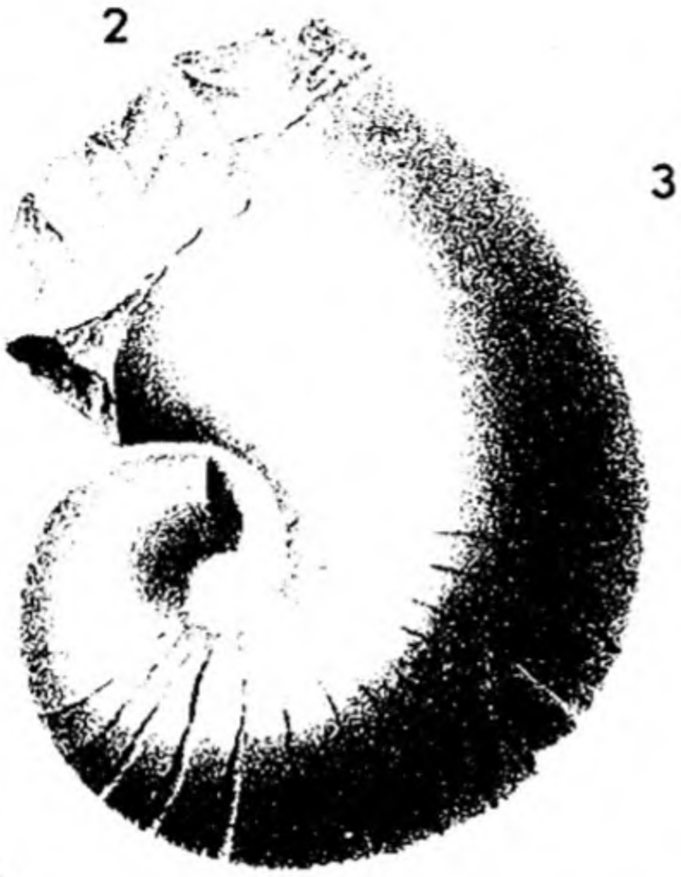

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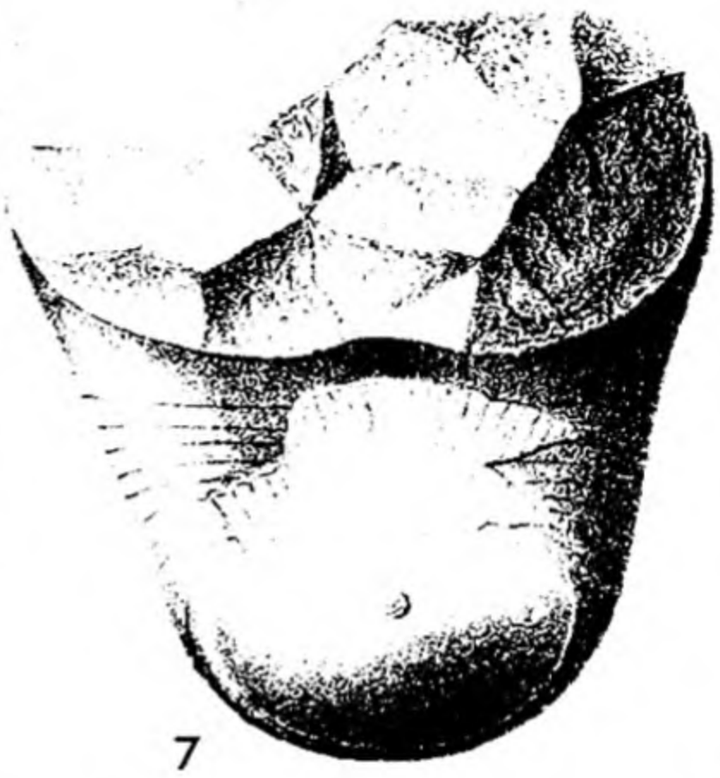

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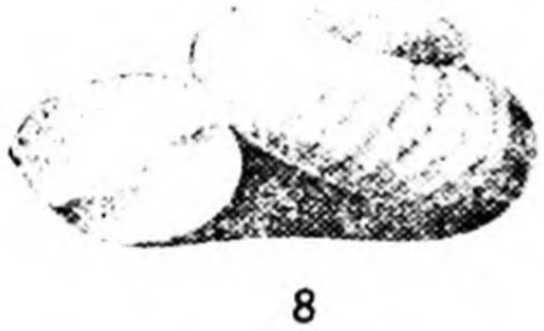

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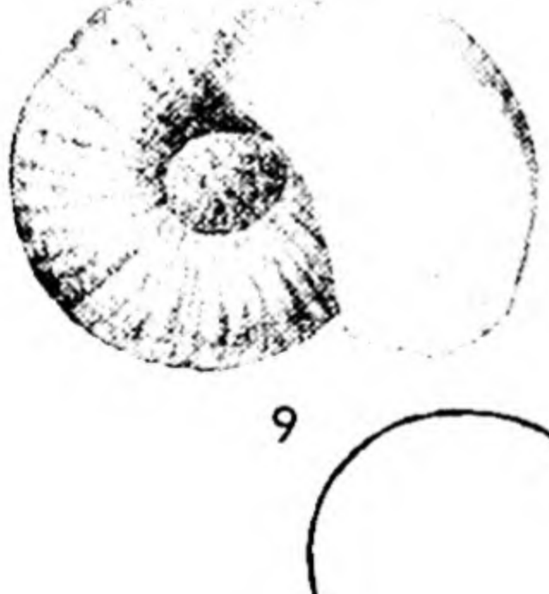

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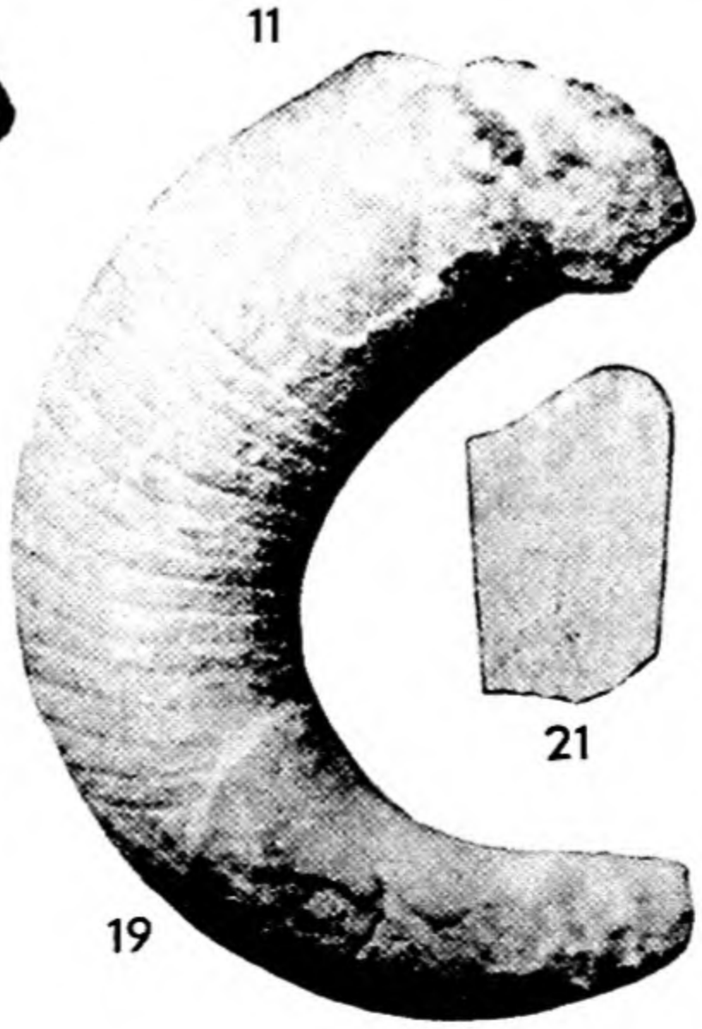

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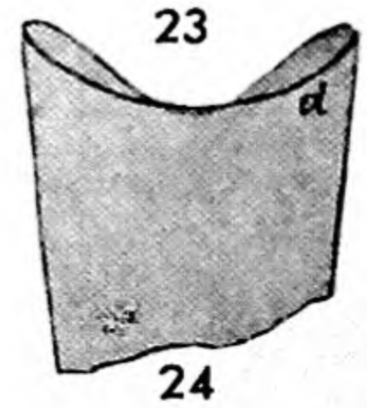

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B. consortale (Hall) (**226**—11). **U. Dev.:** N. Y. and Pa. (Panama, Salamanca), possibly Jennings of Md. and Lime Creek of Ia.

MOOREOCERAS Miller, Dunbar and Condra 1933

(**M. normale*). Conch orthoceraconic, thin, smooth; septa simple disks convex apically; sutures straight or slightly sinuous, transverse to conen axis; siphuncle slightly ventrad of conch center; necks short and strongly recurved; siphuncular segments fusiform to subspherical; connecting rings not touching adjacent septa outside of septal necks; no secondary deposits inside or outside of siphuncle. **Dev.–Penn.** (widespread in eastern two-thirds of U. S. A.).

***M. normale** M, D and C (**226**—14, 15). Widely distributed geographically and stratigraphically in U. S. A. **Penn.:** Ky. (Kendrick), Ill., Mo. (Cherokee, Kansas City), Ark. (Brentwood), Neb. (Chanute, Plattsmouth, Kereford), Kan. (Westerville, Weston, Aspinwall), Okla. (Hale), Colo.

DOLORTHOCERAS Miller 1931

(**D. circulare*). Smooth orthoceracones of circular or slightly depressed section; sutures range from straight and transverse to slightly oblique and sinuous; siphuncle central or subcentral; deposits in siphuncle; cameral deposits are mural and are heavier on venter than on dorsum; hyponomic sinus present; conch surface may bear transverse striae or only fine growth lines. **Dev.–Penn.** (Ont.; Me., N. Y., Ind., Neb.; Asia).

D. exile (Hall) (**226**—6). **Hamilton:** N. Y.

PSEUDORTHOCERAS Girty 1911

(**Orthoceras knoxense* McChesney). Diagnostic features are enlarged siphuncle and especially the secondary deposits accumulated not axially but circumferentially. **Dev.–Penn.** (See below for distribution); **Perm.** of Australia.

***P. knoxense** (McChesney) (**227**–1). Widespread in **Penn.** formations of N. America, ranging from Henrietta to Wabaunsee and from Bend to Cisco in the following states: Pa., W. Va., Ohio, Mich., Ind., Ky., Ill., Ia., Mo. (Cherokee), Ark. (Hale), Neb., Kan. (Drum), Okla. (Nellie Bly), Tex. (Gaptank), Wyo. (Casper), Colo. (Genus also present in **U. Carboniferous** of Carnic Alps on Austro-Italian border.)

EULOXOCERAS Miller, Dunbar and Condra 1933

(***E. greeni**). Orthoceroid; sutures sinuous and distinctly inclined to long axis of conch; septa simple saucer-shaped disks; siphuncle slightly ventrad of conch center. **Penn.**

***E. greeni** M, D and C (**227**—2, 3). **Penn.:** Mo. (Labette), Okla. (Wewoka, Francis, Kansas City), Tex. (Bend, Home Creek, Cisco).

HURONIELLA Foerste 1924

(**Huronia inflecta* Parks). Like *Armenoceras*, but with lateral faces of nummuloidal siphuncular segments presenting more or less distinct concave vertical outlines; intermediate between typical *Armenoceras* and *Huronia*. **Sil.** (Anticosti; Ont.; Mich.).

***H. inflecta** Parks (**227**—5, 6). **Niagaran:** Ont. (Ekwan or Attawapiskat).

HURONIA Stokes 1824

(**H. bigsbyi*). Conchs with large siphuncles, segments of which tend to take form of short, inverted pestles, the annulations forming upper third or two-fifths of segment lengths; typically, lateral outlines of lower and middle parts of segments tend to be about vertical, but in some species these segments contract conspicuously toward their lower ends so that these outlines become oblique; inner margins of septa curve downward but without forming distinct septal necks; segments above and below each septum are adnate to that septum for some distance around passage of more central part of siphuncle through septa; siphuncular annulations directly below septa; septa adnate not only to basal part of siphuncular segments but also to lower and middle of lateral parts of these segments, becoming free from latter where vertical outlines of annulations begin to rise strongly. **Ord., Sil.** (Greenland; Arctic America; Anticosti; Que., Ont.; Mich., Wis., Wyo., Man.; especially characteristic of Silurian).

H. vertebralis Stokes (**227**—7). **L. Sil.:** Anticosti. **M. Sil.:** Drummond Island, Lake Huron.

***H. bigsbyi** Stokes (**227**—8) [**H. bigsbyi intermedia** Foerste (**227**—4)]. **Niagaran:** Mich.

GONIOCERAS Hall 1847

(**G. anceps*). Conch lenticular transversely, ventral side slightly convex or flat, dorsal somewhat more convex; lateral parts or wings of dorsal and ventral sides usually less convex than central part of conch; transverse sections of wings sharply angular at lateral conch margins; sutures curve strongly downward along central part of conch, but arch strongly upward in crossing dorsal and ventral faces of wings;

PLATE 228

[Figures are x1 unless otherwise indicated.]

1, 2. Deiroceras spp. [DUB, JSL 27]. **1. D. python.** Lateral view with ventral outline on left. **2. D. remotiseptum.** Natural section showing siphuncle and septa (x0.5). **3, 4. Gigantoceras** spp. **3. G. inelegans** (x0.25) [Ohio G S 1]. **4. G. cancellatum** (x0.5) [DUB, JSL 21]. **5. Rayonoceras solidiforme** [photograph furnished by C. Croneis]. Longitudinal section showing internal structure. **6, 7. Nephriticeras bucinum** [Pal N Y 5]. Two views of a specimen. **8, 9. Sphyradoceras clio** [Pal N Y 5]. Two views of an incomplete specimen. **10, 11. Oncoceras constrictum** [DUB, JSL 20]. Lateral and ventral views. **12, 13. Tripteroceras planoconvexum** [AMNH, M 1]. Ventral and lateral views. **16–18. Beloitoceras pandion** [DUB, JSL 20]. Lateral view, cross section, and ventral view of a specimen. **19, 20. Richardsonoceras simplex** [DUB, JSL 27]. Lateral and ventral views. **21–24. Tripteroceras hastatum** [DUB, JSL 20]. 21: Diagrammatic lateral view showing lateral saddles. 22: Ventral side exposing siphuncle. 23: View of upper end showing passage of siphuncle through septum. 24: Diagram showing relative depth of dorsal and ventral lobes of sutures.

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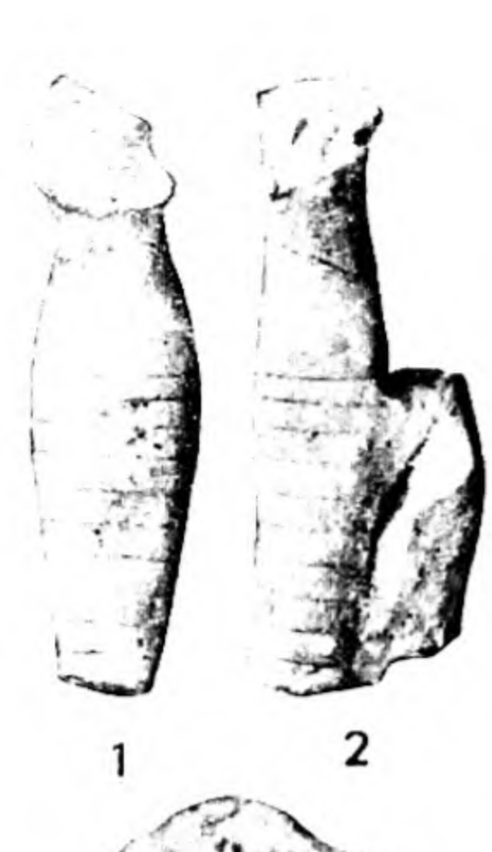

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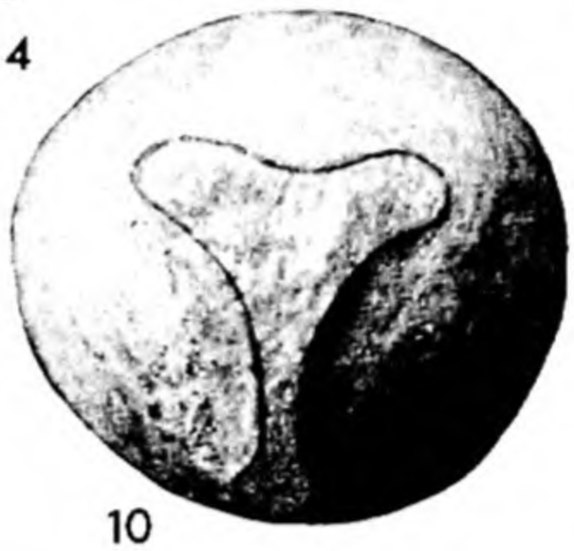

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siphuncle nearer ventral conch wall, segments low, broadly nummuloidal, actinoceroid. **Ord.** (Greenland; Arctic America; Ont.; widespread in U. S. A.).

***G. anceps** Hall (227—15). **Black River:** Ont.; N. Y., Ky., Tenn., Wis., Minn.

LAMBEOCERAS Foerste 1917

(**Gonioceras lambei* Whiteaves). Closely related to *Gonioceras* but differing in transverse section and in course of sutures; conch strongly compressed dorsoventrally, both dorsal and ventral sides convex, the lateral parts of transverse section forming an acute angle, but not thin and sharp as in *Gonioceras;* sutures curve downward both dorsally and ventrally but do not form strongly elevated and conspicuous saddles as in *Gonioceras;* siphuncle near ventral conch wall, actinoceroid. **Ord.** (Greenland; Man.; Ind., Ill., Minn., Wyo.).

***L. lambei** (Whiteaves) (227—11). **U. Ord.:** Minn. (Stewartville); Man. (Red River).

L. confertum Foerste (227—12). **U. Ord.:** Minn. (Stewartville), ?Wyo. (Big Horn).

SACTOCERAS Hyatt 1884

(**Orthoceras richteri* Barrande). "Form genus"; appearance orthoceroid, but with almost globular siphuncular segments, truncated at top and bottom where they meet at septal necks; necks short, internally lined with annular deposits which appear lunate in vertical sections; genus also includes forms with small siphuncles whose segments lack annular deposits. **Ord., Sil.** (Greenland; Ont.; Mich., Ky., Ill., Ia.).

S. josephianum Foerste (227—9, 10). **Black River:** Ont.; Mich.

ORMOCERAS Stokes 1838

(**O. bayfieldi*). Differs from *Actinoceras* in having narrower and less nummuloidal segments and much shorter septal necks; in *Armenoceras* septal necks are entirely lacking and siphuncular segments are distinctly and broadly nummuloidal; a "form genus" in which three distinct types may be recognized: (1) Septal necks sharply bent, large area of adnation; **Ord.** species; (2) septal necks evenly curved, with siphonal deposits in three-fourths of phragmocone; **Sil.** species; (3) septal necks evenly curved, with siphonal deposits in apical fourth or less of phragmocone; **Dev.** species. **Ord.–Dev.** (N. S., Que., Ont.; Mich., Ind., Ky., Tenn.; Man.; Baltic).

O. allumettense (Billings) (227—13, 14). **Black River:** Ont. (Leray).

DEIROCERAS Hyatt 1884

(**Orthoceras python* Billings). Conchs with relatively large siphuncles; segments vertically elongated with elliptical outlines and strongly eccentric in position; siphuncle actinoceroid. **M.** and **U. Ord.** (Que., Ont.; N. Y., Ky., Tenn., Ill., Minn., Mo.).

***D. python** (Billings) (228—1). **Trenton:** Ont.

D. remotiseptum (Hall) (228—2). **Trenton:** N. Y.

RAYONNOCERAS Croneis 1926

(**R. solidiforme*). Actinoceroids with large subventran siphuncles; septal necks rather short compared with length of siphuncular segments; neck brims distinctly free from contact with lower side of septum but only a short distance from latter; siphuncular segments nummuloidal; from their attachment to septal neck brims, connecting rings spread out horizontally for short distance, then curve evenly downward toward contact with septa beneath; area of adnation of rings to upper surface of overlying septa very narrow and almost restricted to downward curved part of septum. **Miss., Penn.** (Ark., Okla., Tex.).

***R. solidiforme** Croneis (228—5). **Fayetteville:** Ark., Okla.

GIGANTOCERAS Hyatt 1900

(**Gyroceras (Nautilus?) inelegans* Meek). Gyroceracones with stout volutions of compressed elliptical form, with long living chamber; siphuncle large, nummuloidal, empty, near center; includes largest known nautiloid shells. **Sil., Dev.** (Ont.; Mich., Ohio, Ind., Wis., Ill.).

G. cancellatum (McChesney) (228—4). **Niagaran:** Wis. (Racine), Ill. (Joliet).

***G. inelegans** (Meek) (228—3). **M. Dev.:** Ont.; Mich. (Dundee), Ohio (Columbus, Delaware, Jeffersonville).

NEPHRITICERAS Hyatt 1884

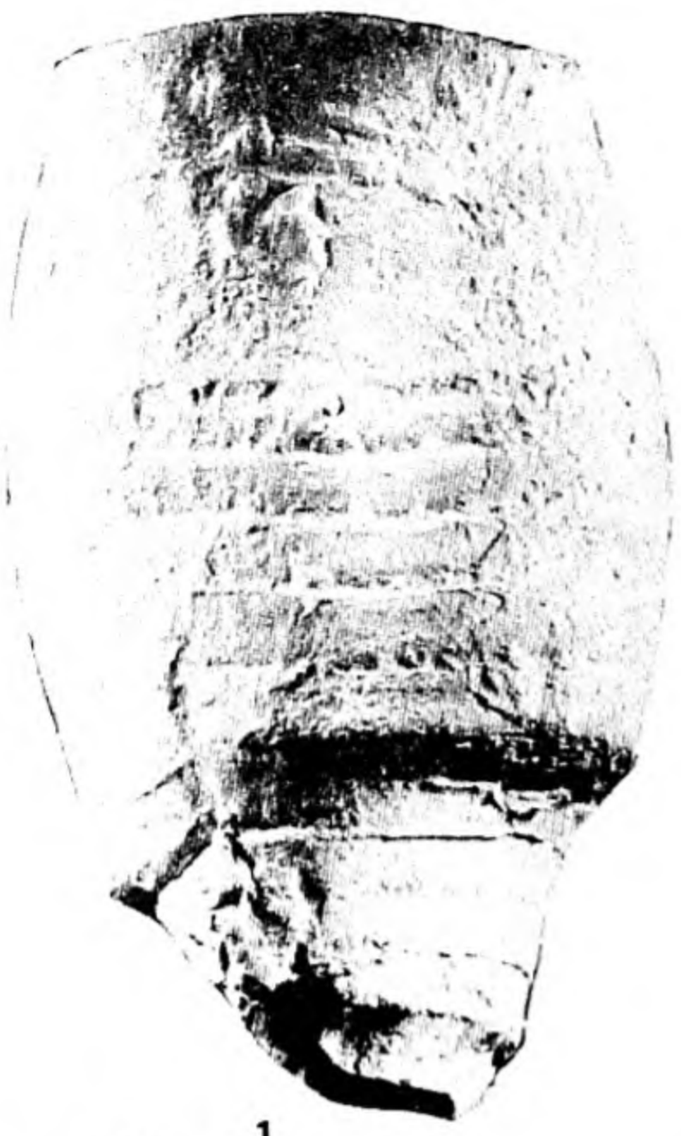
(**Nautilus bucinum* Hall). Gyroceraconic in youth, nautiliconic later; whorls elliptical or reniform in section; umbilicus large; siphuncle nummuloidal, slightly eccentric; sutures with broad ventral saddles in youth and usually with slight ventral lobes later; surface with revolving ridges or striae, or smooth. **Dev.** (Ont.; N. Y., Pa., Md., Ohio, Ind., Ia., Mo.).

***N. bucinum** (Hall) (228—6, 7). Comparatively small; siphuncle near concave dorsum; surface with regular, sharply elevated spirals, four in 10 mm, near

PLATE 229

[Figures are x1 and after Foerste [DUB, JSL 25, 27] unless otherwise indicated.]

1, 2. Whitfieldoceras mumiaforme. Dorsal view, and ventral view with ventral outline on right. **3. Zitteloceras clarkeanum.** Lateral view of an internal filling showing characteristic sinuate transverse surface striae. **4–7. Cyrtorizoceras** spp. **4, 5. C. minneapolis.** Lateral and ventral views, with glimpses of siphuncle. **6, 7. C. fultonense** (x0.5). Lateral view, with ventral outline on right; ventral view. **8, 9. Euryrizoceras chadwicki.** Lateral view with ventral outline on left; ventral view. **10–12. Mandaloceras** spp. **10, 11. M. scrinium** [DUB, JSL 24]. Lateral view with ventral outline on right; apertural view. **12. M. hawthornense.** Ventral view of a nearly complete specimen (x0.5). **13, 14. Amphicyrtoceras pettiti** [DUB, JSL 29]. Lateral view with ventral outline on right; dorsal view. **15. Anglicornus annellesae** [B Am Pal 22]. Ventral aspect of holotype showing siphuncle. **16, 17. Diestoceras indianense** (x0.5) [DUB, JSL 20]. Lateral and ventral views. **18, 19. Amphicyrtoceras orcas** (x0.5) [DUB, JSL 20]. Lateral view with ventral outline on left; ventral view. **20, 21. Acleistoceras hyatti** (x0.5) [N Y Ac Sc, An 5]. Lateral and ventral views.



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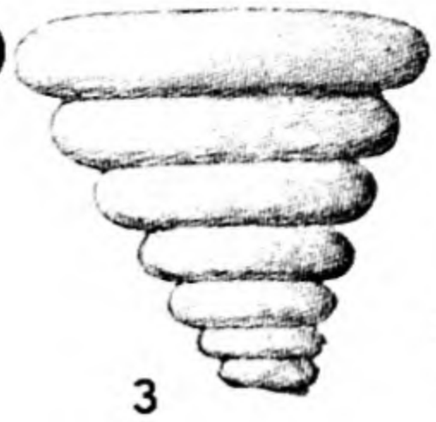

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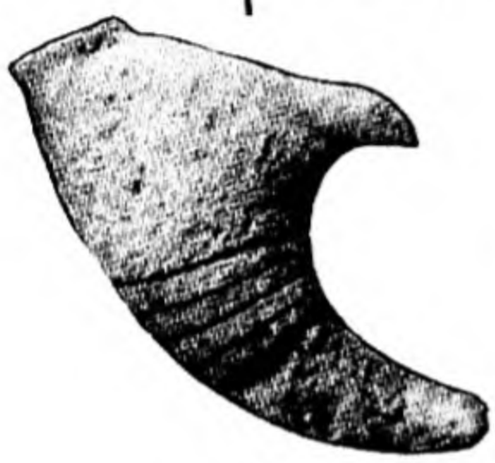

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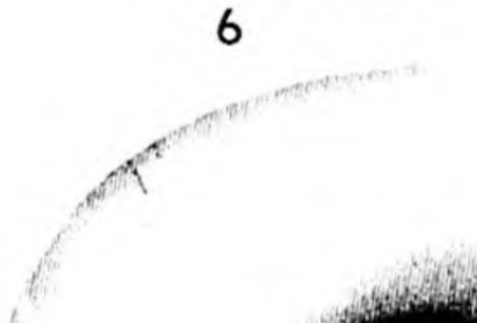

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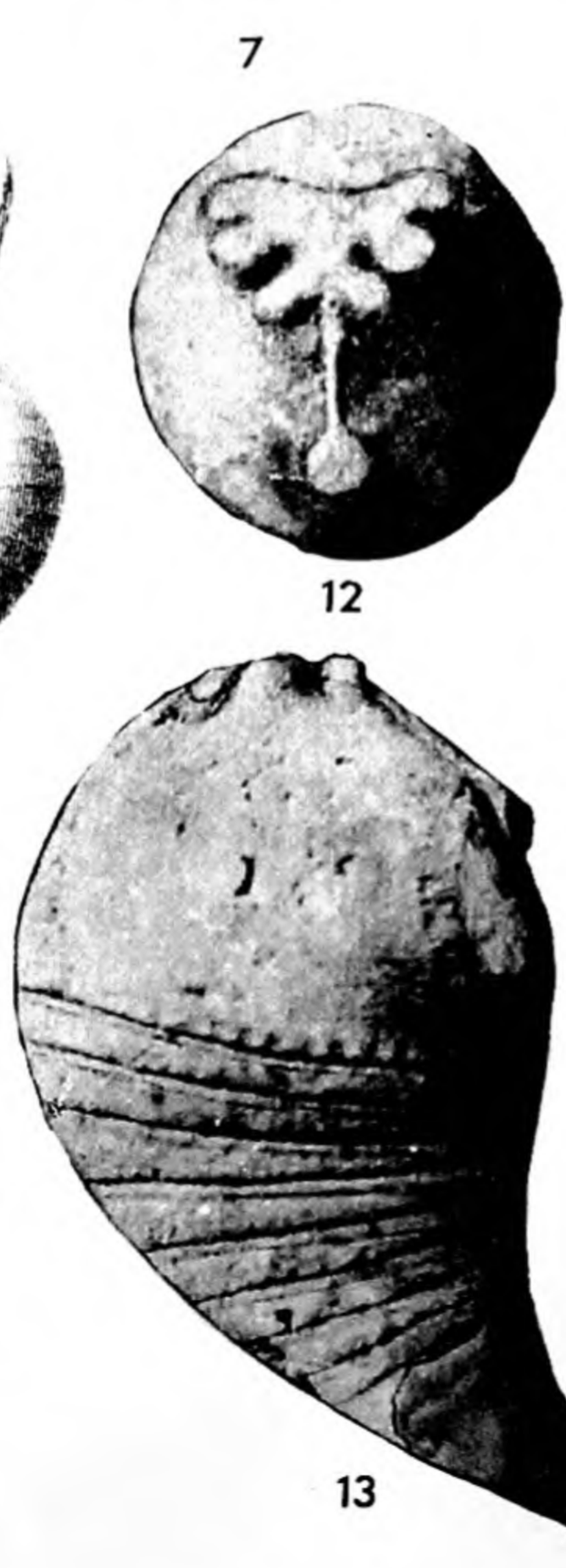

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aperture, with finer spirals between. **Marcellus** and **Hamilton:** N. Y., Pa.; possibly **Hamilton** of Ont. and Md., and **Cedar Valley** of Ia.

SPHYRADOCERAS Hyatt 1884

(**Trochoceras clio* Hall). Costate trochoceracones, last volution often free; costae like those in *Plectoceras*, often with faint longitudinal ridges. **Dev.** (Ont.; N. Y., Mich.).

***S. clio** (Hall) (**228**—8, 9). Sinistrally coiled, forming low spire; costae rounded, slightly sigmoidal, rather faint. **Schoharie:** ?Ont. (along Abitibi River); N. Y., ?Mich.

ALLUMETTOCERAS Foerste 1926

(**Tripteroceras paquettense*). Transverse section like *Tripteroceras*, but less compressed dorsoventrally; lateral sides more broadly rounded, ventral side flattened; siphuncle large, segments nummuloidal as in *Ormoceras*, but apparently touching septa above and below. **L.** and **M. Ord.** (Ont.; Wis., Wyo.)

A. josephianum Foerste (**228**—14, 15). **Black River:** Ont.

TRIPTEROCERAS Hyatt 1884

(**Orthoceras hastatum* Billings). Conch strongly depressed dorsoventrally, strongly flattened ventrally, and sufficiently flattened along two halves of dorsal side to produce distinct angularity along median part; lateral angles of transverse section narrowly rounded or obscurely truncated; siphuncle small, endogastric. **Ord.** (Anticosti; Ont.; Ind., Wis., Minn.; Man.; Mo., Wyo.).

***T. hastatum** (Billings) (**228**—21–24). **Black River–Trenton:** Ont. (Leray).

T. planoconvexum (Hall) (**228**—12, 13). **Black River:** Wis., Minn., Mo.

BELOITOCERAS Foerste 1933

(**Oncoceras pandion* Hall). Conch short, strongly compressed laterally, ventral side more narrowly rounded; apertural margins arching upward laterally or ventrolaterally, but curving downward rather strongly at hyponomic sinus; upper part of aperture often constricted by thickening of shell wall near top of living chamber; siphuncle medium-sized, almost touching ventral wall. **Ord.** (Arctic America; Ont.; Wis., Ill., Minn., Ia., Wyo.).

***B. pandion** (Hall) (**228**—16–18). **Black River** (Platteville): Wis., Minn.

ONCOCERAS Hall 1847

(**O. constrictum*). Conch short, rapidly enlarging, strongly curved lengthwise, with maximum dimensions at top of phragmocone and base of living chamber, contracting thence adaperturally; general dorsal outline concave; aperture oval in outline; hyponomic sinus distinct but shallow; siphuncle near ventral conch wall, its segments narrowly fusiform. **Ord., Sil.** (Arctic America; Anticosti; Que., Ont.; N. Y., Wis., Ill., Minn., Wyo.; Man.).

***O. constrictum** Hall (**228**—10, 11). **Trenton:** N. Y.

RICHARDSONOCERAS Foerste 1933

(**Cyrtoceras simplex* Billings). Like *Beloitoceras*, but enlarging less rapidly in dorsoventral direction and hence more elongate; dorsal outline of living chamber more concave in continuation of concave outline of phragmocone; siphuncle somewhat larger. **M. Ord.** (Que., Ont.; Wis., Wyo., Colo.).

***R. simplex** (Billings) (**228**—19, 20). **Black River:** Ont.

WHITFIELDOCERAS Foerste 1933

(**Oncoceras mumiaforme* Whitfield). Conchs small, enlarging as far as base of living chamber, then contracting adaperturally; lengthwise curvature small; transverse section generally circular; siphuncle small, ventrad of conch center; siphuncular segments moniliform. **M.** and **U. Ord.** (Arctic America; Ont.; N. Y., Wis., Ill., Minn., Ia., Wyo.).

***W. mumiaforme** (Whitfield) (**229**—1, 2). **Black River** (Platteville): Wis., Ill., Minn.

ZITTELOCERAS Hyatt 1884

(**Cyrtoceras lamellosum* Hall = *Cyrtoceras hallianus* Orbigny). Cyrtoceraconic; transverse section essentially circular; sutures faintly curved downward laterally, rising in ventrad direction; siphuncle near or touching ventral conch wall; shell surface ornamented with frilled growth lamellae that are alternately fine and coarse; on median part of venter, lamellae curve forward to form a narrow V-shaped hyponomic sinus. **Ord.** (Que., Ont.; N. Y., Wis., Minn., Mo.).

Z. clarkeanum Foerste (**229**—3). Compared with typical **Z. hallianum* (Orbigny), from the **Trenton** of New York, this species has a larger conch which curves more strongly and enlarges more rapidly. **Black River:** Wis. (Platteville). **Z. billingsi** (Salter) is smaller than *Z. clarkeanum* and has lirae rather smooth instead of frilled. **Black River:** Que. (Leray); Minn. (Platteville), Mo. (Auburn).

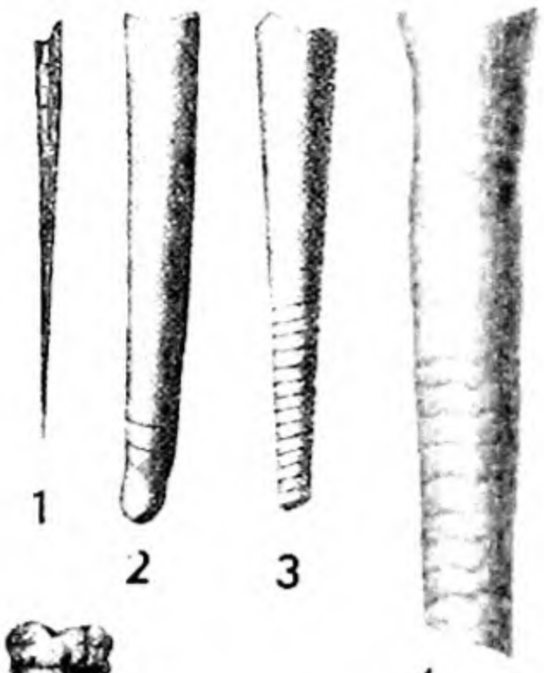
CYRTORIZOCERAS Hyatt 1900

(**Cyrtoceras minneapolis* Clarke). Breviconic cyrtocones, laterally compressed; living chambers not

PLATE 230

[Figures are x1 unless otherwise indicated.]

1. Brevicoceras casteri [Pal Am 2 (9)]. Dorsal view of holotype. **2. Westonoceras nelsonense** [DUB, JSL 24]. Diagonally lateral view, with ventral outline on left where sutures rise into low angular saddles (x0.5). **3, 4. Discosorus conoideus** [U Mich Mus G, Contr 2]. Dorsal and lateral views of siphuncle. **5. Eleusoceras nicholsi** [Pal Am 2 (9)]. Dorsal view of holotype. **6. Phragmoceras parvum** [DUB, JSL 24]. **7, 8. Ovoceras oviforme** [Pal N Y 5]. Apertural and lateral views. **9. Naedyceras eugenium** (x0.5) [Pal N Y 5]. **10, 11. Phragmoceras nestor** (x0.5) [N Y St Mus, An Rp 20]. Apertural and lateral views. **12, 13. Hexameroceras hertzeri** [DUB, JSL 24]. Apertural and lateral views. **14. Cyrtogomphoceras thompsoni** [JP 11]. Lateral view of holotype (x0.2). **15. Charactoceras baeri** (x0.5) DUB, JSL 20]. **16. Discosorus austini** [DUB, JSL 29]. Ventral view exposing siphuncle and lower part of living chamber.



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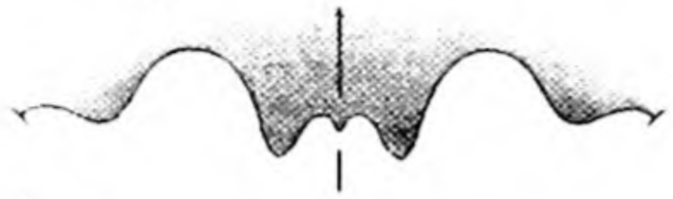

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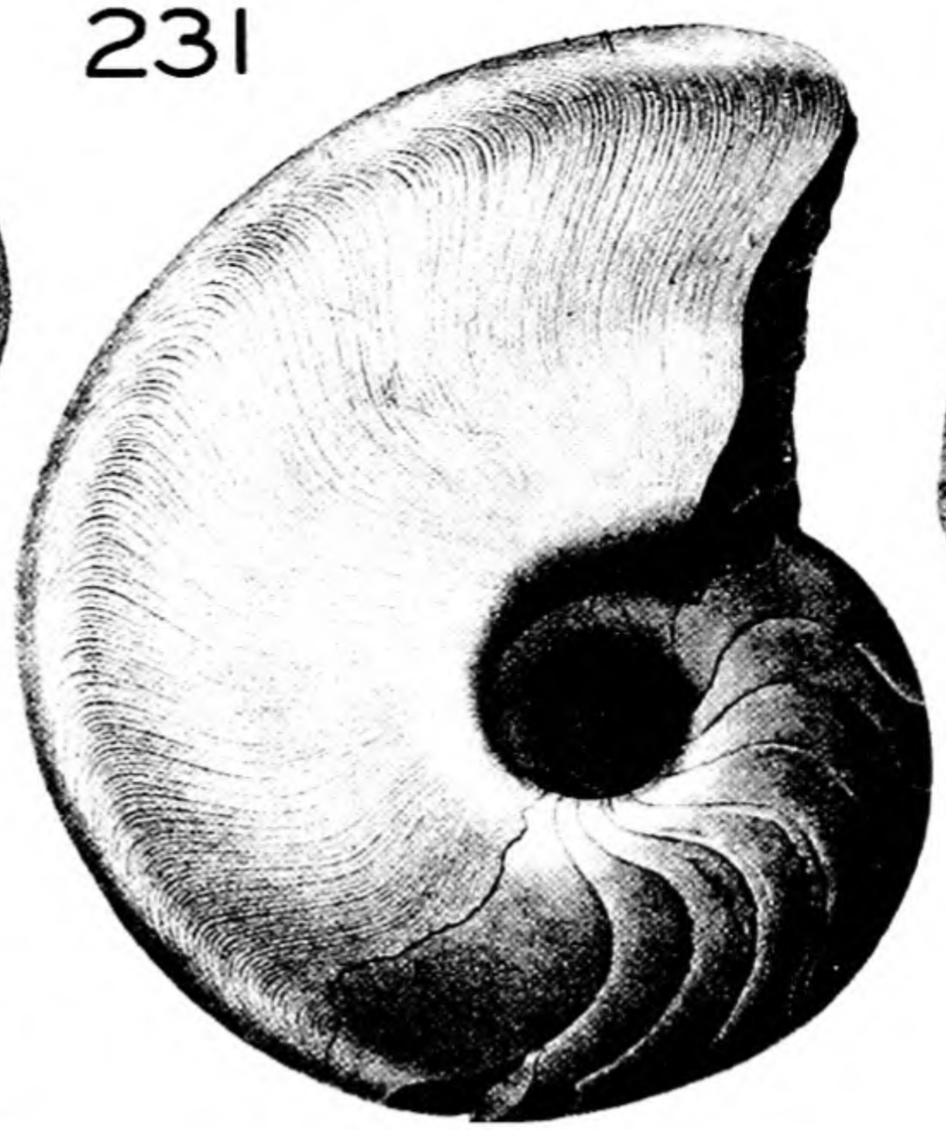

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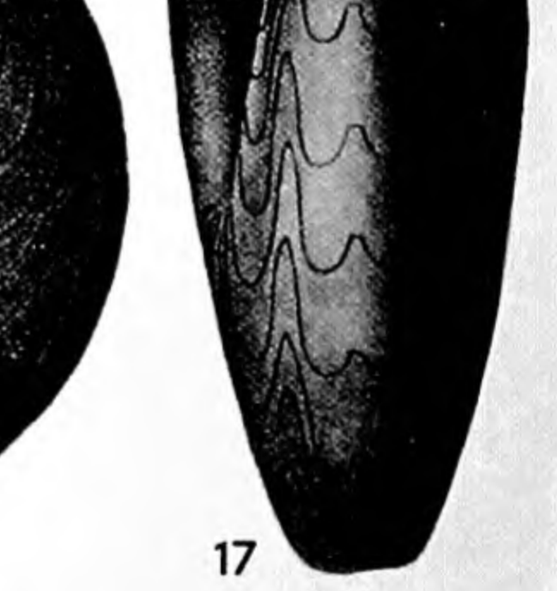

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contracted aperturally; sutures curving downward laterally, forming broad lateral lobes and distinctly narrow dorsal and ventral saddles, the latter much the more conspicuous; siphuncle near venter, its segments fusiform, narrowing downward; shell surface transversely striated and not annulated, though some forms have oblique ribs indicating former presence of a deep hyponomic sinus. **Ord., Sil.** (Que., Ont.; N. Y., Ohio, Wis., Ill., Minn.).

***C. minneapolis** (Clarke) (**229**—4, 5). **Black River:** Minn.

C. fultonense (Meek and Worthen) (**229**—6, 7). **Niagaran:** Ill.

EURYRIZOCERAS Foerste 1930

(**E. chadwicki*). Cyrtoconic, with concave dorsal and convex ventral outline; siphuncle near but not touching ventral conch wall; segments abruptly constricted at septal necks as in *Amphicyrtoceras*, but presenting a less elongated appearance within camerae. **Sil., ?Dev.** (Ont.; N. Y., ?Mich., Ohio, Ill.).

***E. chadwicki** Foerste (**229**—8, 9). **Niagaran:** Ill. (Port Byron).

E. orodes (Billings). **Niagaran:** Ont.; N. Y.; possibly Detroit River of Ont. and Mich.

MANDALOCERAS Hyatt 1900

(**Gomphoceras bohemicum* Barrande). Conch erect, with ventral outline distinctly but moderately more convex than dorsal; aperture T-shaped, all parts narrowly contracted both medially and dorsolaterally; nummuloidal siphuncle halfway between conch center and ventral wall. **Sil.** (Que.; Ohio, Ill.).

M. hawthornense Foerste (**229**—12). **Niagaran:** Ill. (Racine).

M. scrinium (Hall) (**229**—10, 11). Same as preceding.

DIESTOCERAS Foerste 1924

(**Gomphoceras indianense* Miller and Faber). Characterized by distinct downward curvature of its transverse striae along ventral side of conch, indicating presence of very shallow hyponomic sinus, with tendency toward distinct angulation along median line of this side. **Ord.** (Greenland; Arctic America; Que., Ont.; Mich., Ohio, Ind., Minn., S. Dak., Mont., Wyo., Colo.; Man.).

***D. indianense** (M and F) (**229**—16, 17). **Richmond:** Ohio (Whitewater), Ind. (Saluda).

AMPHICYRTOCERAS Foerste 1924

(**Oncoceras orcas* Hall). Conch subfusiform; transverse section depressed dorsoventrally; sutures slope slightly downward ventrally; siphuncle endogastric, segments usually barrel-shaped within camerae, though abruptly contracted at septal necks. **M. Sil.** (Anticosti; Que., Ont.; N. Y., Ohio, Ill., Wis.).

***A. orcas** (Hall) (**229**—18, 19). **Niagaran:** Wis. (Waukesha).

A. pettiti (Billings) (**229**—13, 14). **Niagaran:** Ont. (Lockport).

ACLEISTOCERAS Hyatt 1884

(**Apioceras olla* Saemann). Conch nearly straight, ventral outline more convex than dorsal; apertural outline distinctly triangular; siphuncular segments nummuloidal, with strongly convex lateral outline but strongly flattened at top and bottom in direction parallel to septa and overlapping in stairlike manner; siphuncle endogastric. **Dev.** ("Form genus" with species reported from Que., Ont.; N. Y., Md., Mich., Ohio, Ind., Wis., Ill., Ia., Mo., Nev.).

A. hyatti Whitfield (**229**—20, 21). **Dev.:** Mich. (Dundee), Ohio (Columbus).

ANGLICORNUS Flower and Caster 1935

(**A. anneliesae*). Conch erect, dorsal outline more convex than ventral; greatest gibbosity midway between last septum and dorsal part of aperture and near base of hyponomic sinus on ventral aperture; slight flaring or reversal of curvature just below aperture, a character which with ventral siphuncle distinguishes this from other breviconic genera; siphuncle ventral, touching conch wall. **Dev.**

***A. anneliesae** F and C (**229**—15). **Dev.:** Pa. (Venango, Salamanca).

BREVICOCERAS Flower 1938

(**B. casteri*). Superficially resembling *Acleistoceras*, but differing in having narrow small hyponomic sinus, more flattened dorsum, more sinuate sutures, and proximity of greatest gibbosity to base of living chamber. **Dev.** (N. Y., Schoharie through West River; Ohio, Mich., Ind., Wis., Ia.).

***B. casteri** Flower (**230**—1). **Dev.:** N. Y. (Moscow).

OVOCERAS Flower 1936

(**Gomphoceras* (*Apioceras*) *oviforme* Hall). Conch small, short and thick, ovoid, with broadly oval to subcircular section; sides of adult portion nearly parallel; aperture contracted and trilobate; surface with lamellose growth lines; siphuncle endogastric. **Dev.** (N. Y., Ohio, Ind., Ky.).

PLATE 231

[Figures are x1 and after Miller [GSA, SP 14] unless otherwise indicated.]

1–4. Bactrites spp. 1, 2. B. aciculum. A typical specimen; and a questionable specimen (x12.5) showing early adolescent stage. **3. B. arkonensis.** A composite drawing. **4. B. gracilior.** Ventral view. **5. Probeloceras lutheri.** Lateral view of a mature specimen. **6–8. Mantiloceras simulator.** Diagrammatic suture, and ventral and lateral views. **9, 10. Agoniatites vanuxemi** (x0.5). Lateral and ventral views of two specimens. **11. Lobobactrites clavus.** Ventral view. **12–15. Tornoceras spp. 12, 13. T. (Tornoceras) uniangulare.** Ventral and lateral views. **14, 15. T. (Parodoceras) discoideum.** Ventral and lateral views. **16, 17. Manticoceras sinuosum.** Lateral and ventral views. **18, 19. Prolecanites greenii** [USGS, M 42]. Ventral and lateral views. **20. Platyclymenia (Pleuroclymenia) americana.** Lateral view of a large specimen (x2), with inner volutions missing. **21–23. Protocanites lyoni** [JP 10]. Diagrammatic suture (x2), and ventral and lateral views.

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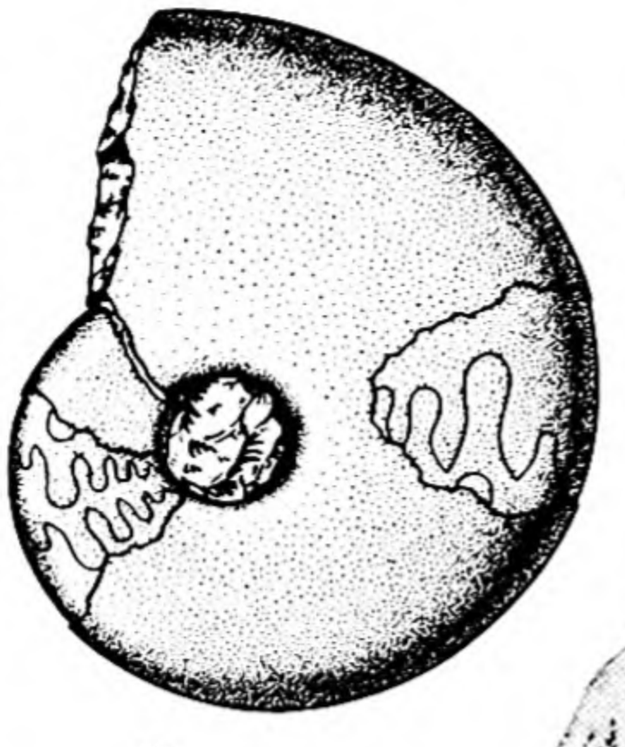

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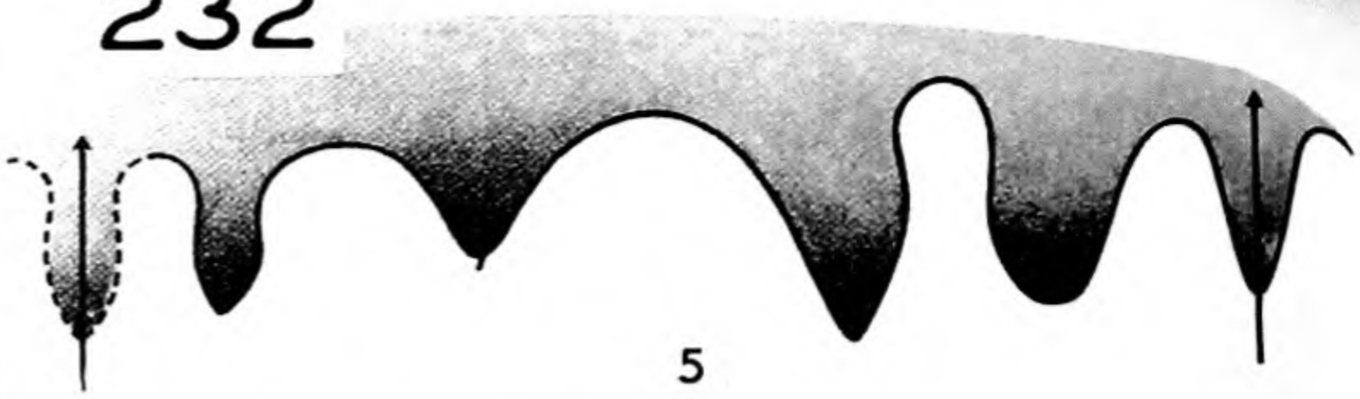

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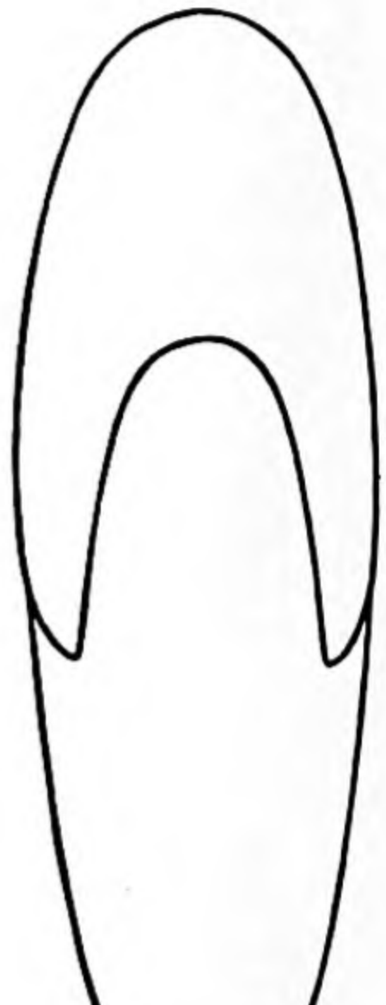

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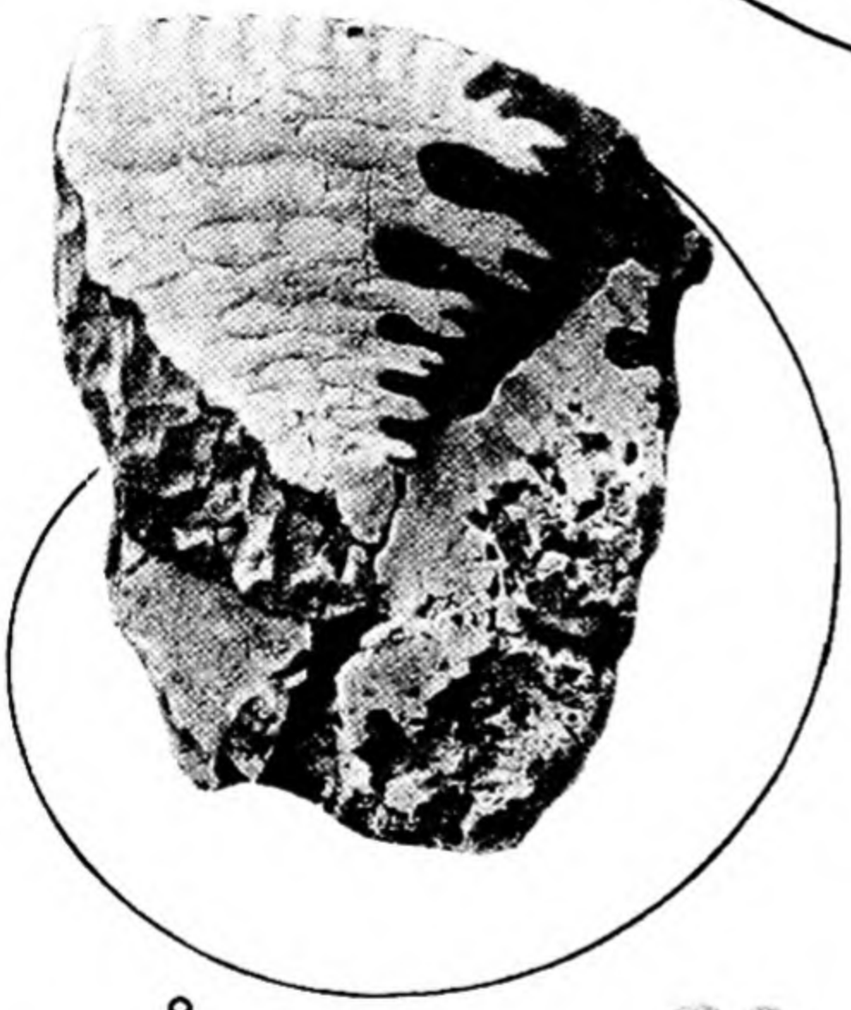

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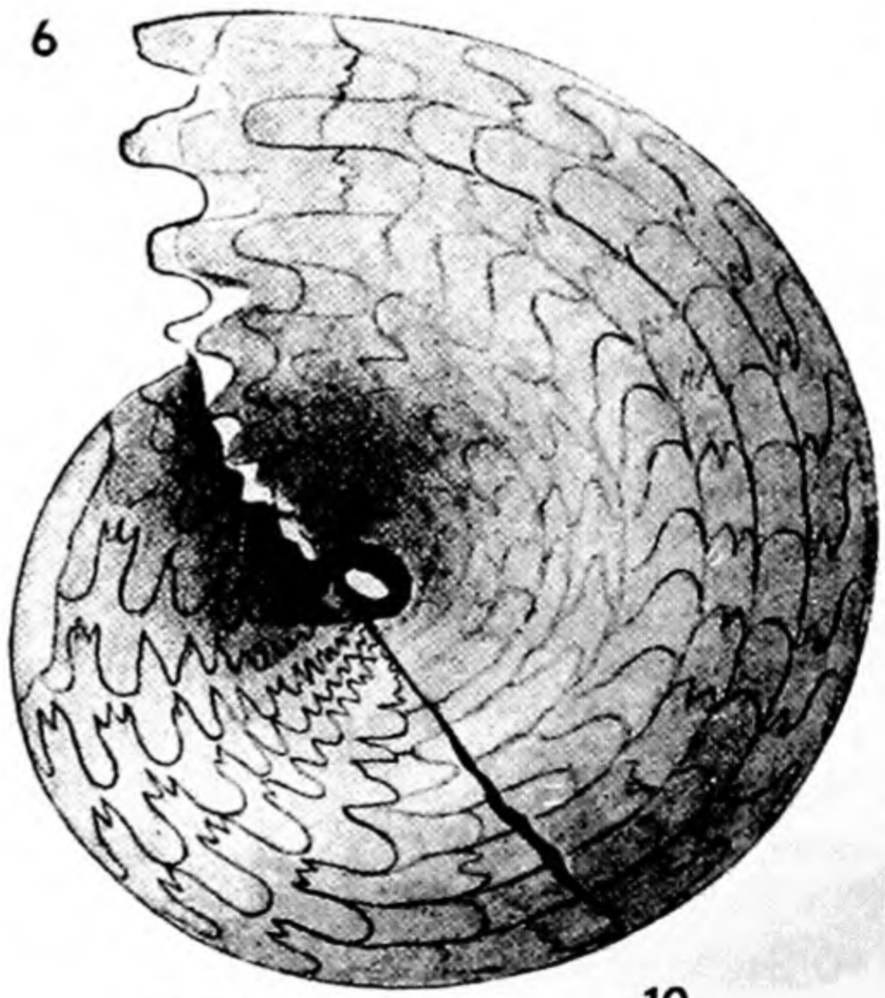

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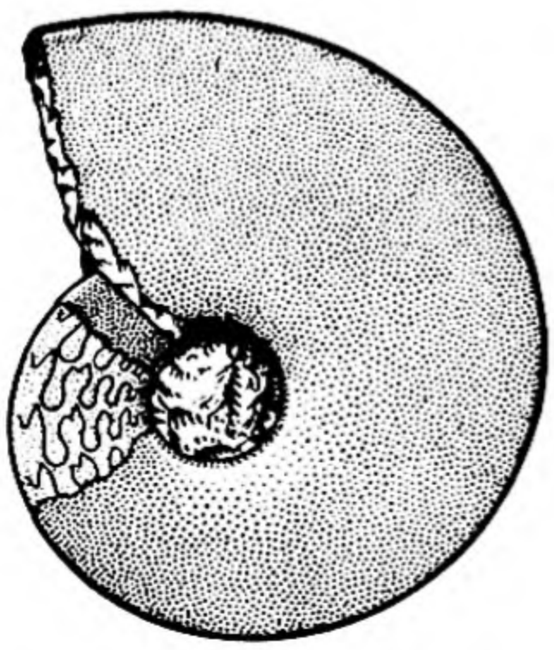

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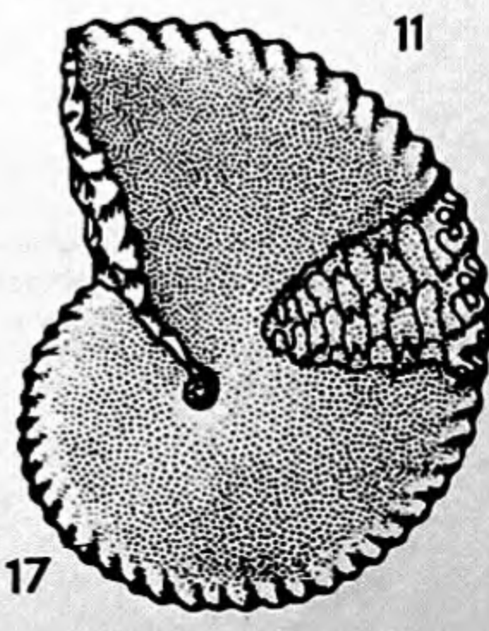

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***O. oviforme** (Hall) (**230**—7, 8). **Dev.:** N. Y. (Cherry Valley), possibly Ohio (Sellersburg).

ELEUSOCERAS Flower 1938

(**E. nicholsi*). Conch erect, probably exogastric, breviconic; section circular to slightly depressed; sutures straight and transverse; siphuncle near venter, segments nummuloidal; brims and adoral ends of connecting rings recumbent, apical ends free; siphuncle actinosiphonate; no hyponomic sinus. **M. Dev.** (N. Y., Ohio, Ind., Wis.).

***E. nicholsi** Flower (**230**—5). **Schoharie:** N. Y.

WESTONOCERAS Foerste 1924

(**Cyrtoceras manitobense* Whiteaves). Conch with convex ventral outline; transverse section laterally compressed; sutures curve downward laterally; siphuncle near ventral conch wall; siphuncular segments barrel-shaped; septa horizontal near siphuncle, but near septal foramen they curve very slightly upward and then recurve very sharply and suddenly downward and outward; brim for its entire length in close contact with lower side of septum. **Ord.** (Greenland; Arctic America (Baffin Land, Labrador, etc.); Ont., Man.; Ohio, Minn., Ia., Mo., Okla.).

W. nelsonense Foerste (**230**—2). **Red River:** Man.

DISCOSORUS Hall 1852

(**D. conoideus*). Siphuncle is distinctly curved lengthwise, with convex outline in contact with ventral conch wall; rapid rate of enlargement of siphuncle indicates a similar enlargement of conch; siphuncular segments rise in ventrad direction, their form nummuloidal, low and broad; their dorsal and lateral vertical outlines evenly rounded but their ventral part thins ventrad, chiefly owing to flattened adnation of lower face of segments to upper surface of septa immediately beneath, so that vertical thickness of segments decreases on approaching ventral conch wall. **Sil.** (a very widespread and important genus, occurring from Arctic America across eastern Canada into central U. S. A.).

***D. conoideus** Hall (**230**—3, 4). **Lockport:** N. Y.

D. austini Foerste (**230**—16). **Clinton:** Ohio (Dayton).

NAEDYCERAS Hyatt 1884

(**Trochoceras eugenium* Hall). Gyroceracones and trochoceracones with whorls of subtriangular section; nummuloidal siphuncle near venter; sutures with pronounced dorsal lobe, no annular lobes, and no impressed zone. **Sil., Dev.** (N. Y., Ill., Ia.).

***N. eugenium** (Hall) (**230**—9). Aperture contracted, opening directly outward. **Schoharie:** N. Y.

CYRTOGOMPHOCERAS Foerste 1924

(**Oncoceras magnum* Whiteaves). Siphuncle endogastric; dorsal outline conspicuously convex, ventral concave along lower part of phragmocone, but distinctly though moderately gibbous along upper part of phragmocone and lower part of living chamber. **M.** and **U. Ord.** (Arctic America; Greenland; Man.; S. Dak., Wyo.; Estonia).

C. thompsoni Miller and Furnish (**230**—14). **Ord.:** S. Dak. (Whitewood).

PHRAGMOCERAS Broderip 1839

(**P. arcuatum* Sowerby). Conch strongly compressed laterally, strongly curved lengthwise, with siphuncle on concave ventral side; except at dorsal end, aperture of living chamber contracted by strong inward curvature of its dorsolateral crests to narrow slit, terminating ventrally in slightly enlarging hyponomic sinus, which forms upper margin of projecting lip or spout; at dorsal end this slit widens abruptly into an elliptical dorsal lobe, distinctly wider laterally than long dorsoventrally; dorsal margin of lobe evenly convex in outline; margin of lobe rises diagonally upward and backward in form of short collar; shell surface with transverse striae which curve more strongly down dorsally than ventrally, but hyponomic sinus is ventral; siphuncular segments nummuloidal. **Sil.** (Anticosti; Que., Ont.; N. Y., Ohio, Ind., Wis., Ill.; Man.).

P. nestor Hall (**230**—10, 11). **Niagaran:** Ont. (Guelph, var. **canadense**), Ind. (Huntington), Wis. (Racine).

P. parvum Hall and Whitfield (**230**—6). **Niagaran:** Ont. (Guelph), N. Y. (Rochester), Ohio (Cedarville), Ind. (Huntington).

HEXAMEROCERAS Hyatt 1884

(**Phragmoceras panderi* Barrande). Aperture contracted and multilobate; dorsal lobe contracted to six sinuses; two dorsal ones are short and directed straight backward, while ends of two dorsolateral ones curve slightly backward, and two anterolateral ones face in anterolateral direction; siphuncle contains converging vertical lamellae. **Sil.** (Que.; Ohio, Ind., Wis., Ill.).

H. hertzeri (Hall and Whitfield) (**230**—12, 13). **Niagaran:** Ohio (Cedarville).

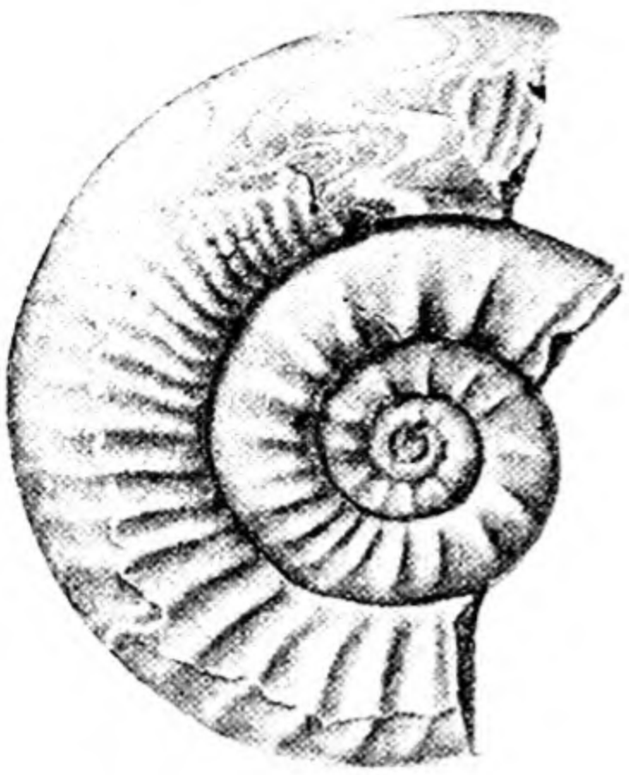
CHARACTOCERAS Foerste 1924

(**Trochoceras? baeri* Meek and Worthen). Conch nautiloid, depressed dorsoventrally, with distant dorsal impressed zone; transverse striae on shell surface indicate that hyponomic sinus was broad

PLATE 232

[Figures are x1 and after Miller and Furnish [GSA, SP 26] unless otherwise indicated; original drawings furnished by Miller and Furnish are indicated by M and F.]

1, 2. Pronorites arkansasensis [M and F]. Ventral and lateral views. **3, 4. Uddenites schucherti.** Two views (x3) of a fragmental specimen. **5–7. Sporadoceras milleri** [GSA, SP 14]. Suture, and lateral and ventral aspects of holotype. **8, 9. Propinacoceras knighti.** Ventral (x3) and lateral views of two specimens. **10, 11. Prodromites gorbyi** [USGS, M 42]. Lateral and ventral views. **12, 13. Prouddenites primus** [M and F]. Lateral and ventral views. **14–17. Artinskia** spp. **14, 15. A. huecoensis.** Views of two specimens (x2). **16, 17. A. whortani** [M and F]. Ventral and lateral views.



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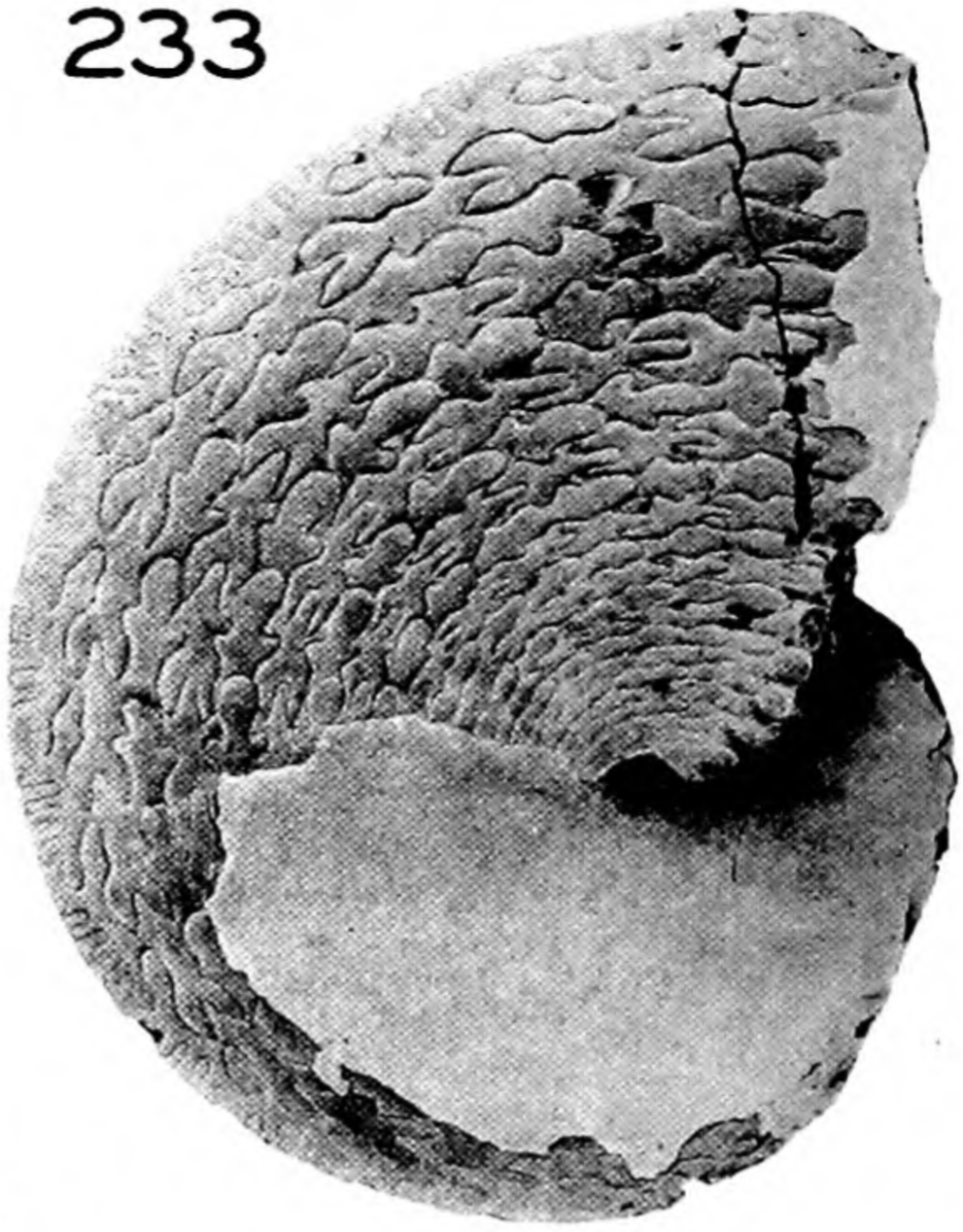

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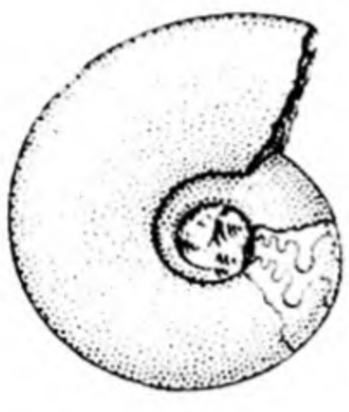

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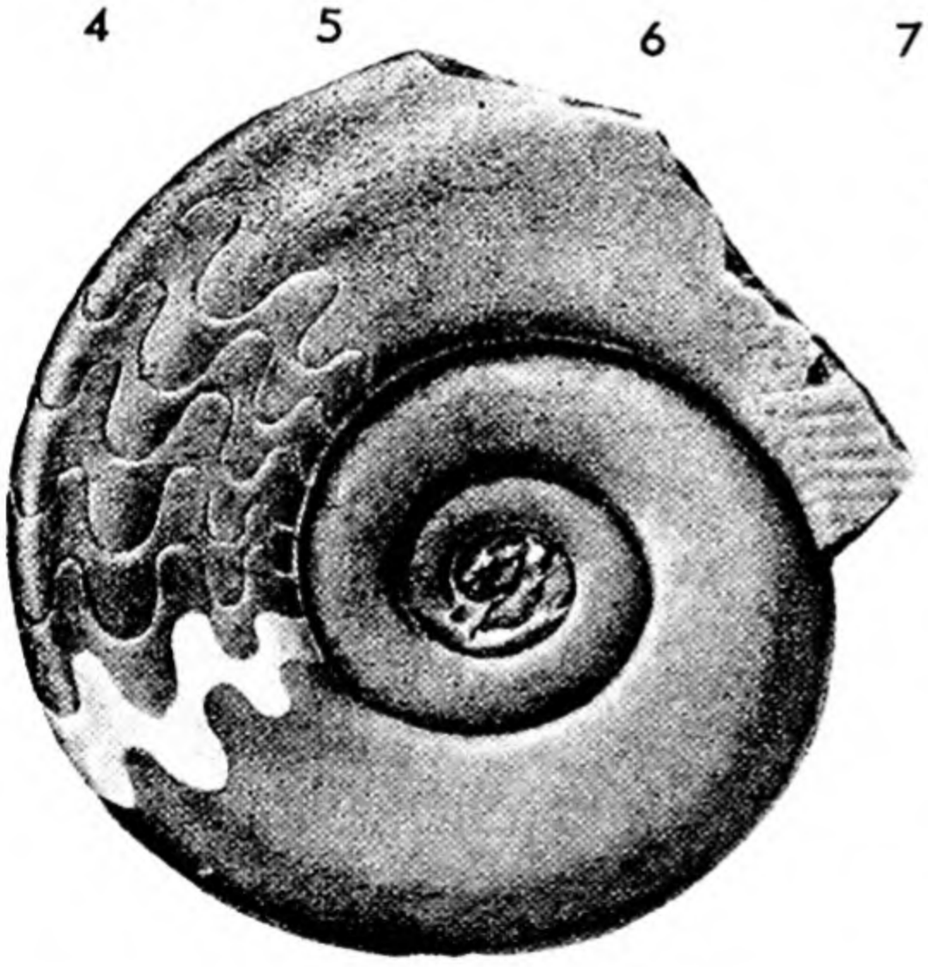

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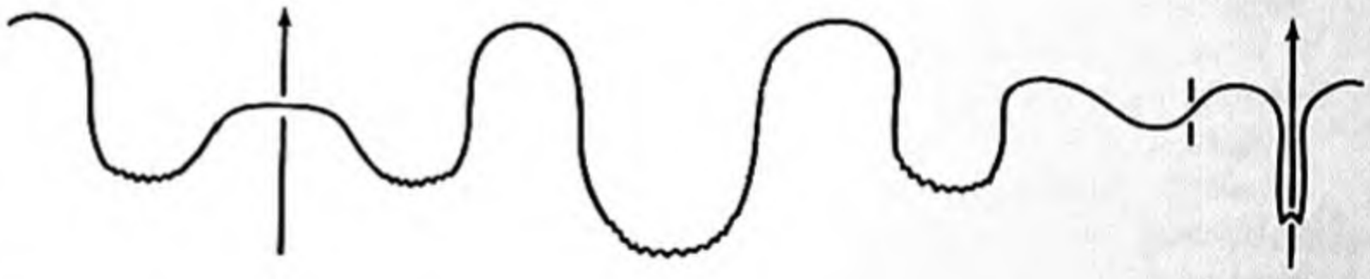

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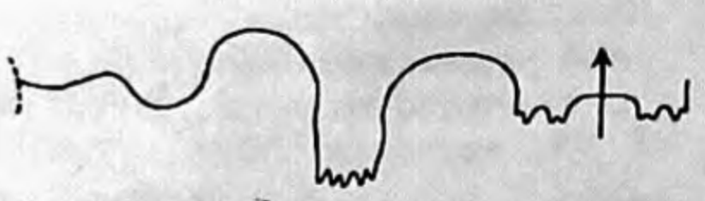

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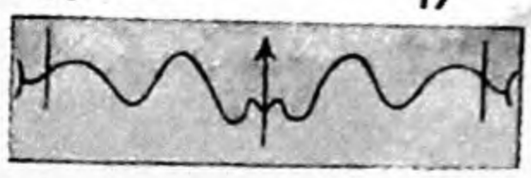

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and relatively deep, but not abrupt; siphuncle near ventral conch wall, segments enlarge but moderately within camerae, presenting elliptical outlines elongated in direction parallel to central conch axis. **M. and U. Ord.** (Greenland; Arctic America; Anticosti; Ohio, Ind., Ill., Ia., Mo., Colo.).

***C. baeri** (M and W) (230—15). **U. Ord.:** Greenland (Cape Calhoun); Ohio and Ind. (Whitewater), Ill. and Mo. (Fernvale).

Subclass Ammonoidea [1]

Shells calcareous, external, usually complexly coiled (differ from Nautiloidea in being thinner and more discoidal and having complexly folded septa); apertures closed by single or double horny plate, rarely modified; siphuncle retrosiphonate, transitional and prosiphonate; umbilical perforation rare. **U. Sil.–Cret.**

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[1] **Adkins, W. S.,** Some Upper Cretaceous Taylor ammonites from Texas: *U Tex B* 2901: 203–222, il, 1929. **Boese, E.,** Permo-Carboniferous ammonoids of the Glass Mountains, West Texas: *Idem* 1762: 1–241, il, 1917; New ammonite fauna of Lower Turonian of Mexico: *Idem* 1856: 173–252, il, 1918; Ammonoids from Abo sandstone of New Mexico: *AJS* (4) 49: 51–60, 1920; Cretaceous ammonites from Texas and northern Mexico: *U Tex B* 2748: 143–312, il, 1927. **Buckman, S. S.,** Jurassic Ammonoidea: *Can Nat Mus.* B 58: 1–27, 1929. **Burckhardt, C.,** La Fauna Jurasique de Mazapil: *Inst G Mex*, B 23, 1–216, il, 1906; Faunas jurasicas de Symon (Zacatecas): *Idem*, B 33: 1–135, il, 1919; Faunas del Aptiano de Nazas, (Durango): *Idem*, B 45: 1–71, il, 1925; Cefalópodas del jurásico medio de Oaxaca y Guerrero: *Idem*, B 47: 1–108, il, 1927. **Crickmay, C. 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PLATE 233

[Figures are x1 unless otherwise indicated.]

1, 2. Paraceltites ornatus (x2) [GSA, SP 26]. **3–5. Xenaspis marcoui** (x2) [USGS, PP 40]. Septa, lateral view, and cross section. **6, 7. Boesites texanus** [original drawing furnished by Miller and Furnish]. **8, 9. Medlicottia whitneyi** (x2) [GSA, SP 26]. Two views of a well preserved specimen. **10. Xenodiscites waageni** [GSA, SP 26]. Diagrammatic complete suture (x5) at diameter of about 28 mm. **11, 12. Xenaspis skinneri** [GSA, SP 26]. A nearly complete specimen (x2), and diagrammatic complete suture (x5) at diameter of about 30 mm. **13–15. Xenodiscus waageni** [USGS, PP 167]. Two views of type, and septum (x3). **16–18. Eumorphoceras bisulcatum** [USGS, B 377]. Two views of an exfoliated specimen (x2), and septum (x3). **19, 20. Muensteroceras parallelum** [USGS, M 42]. **21–23. Ophiceras subquadratum** [USGS, PP 167]. Two views of type, and septum (x4).

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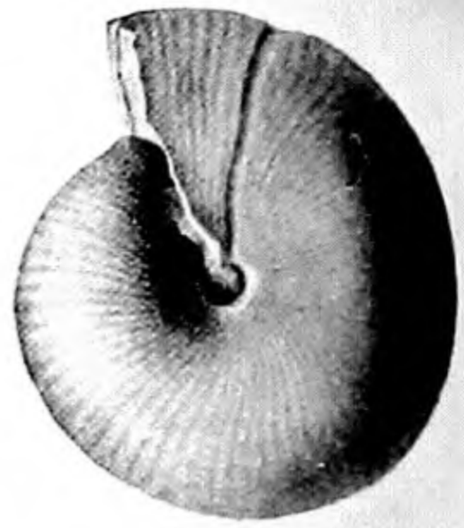

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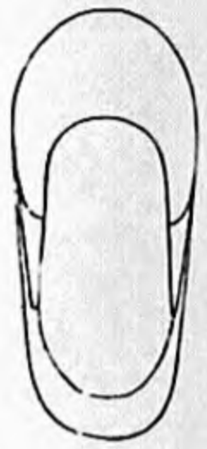

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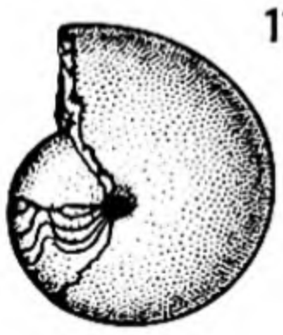

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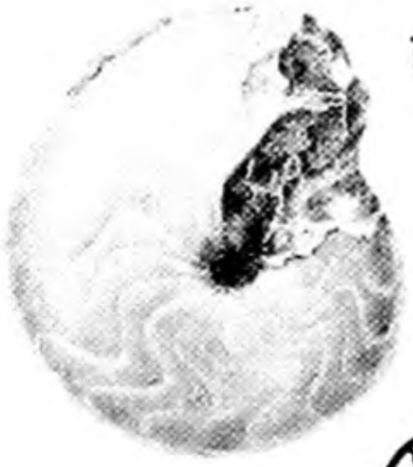

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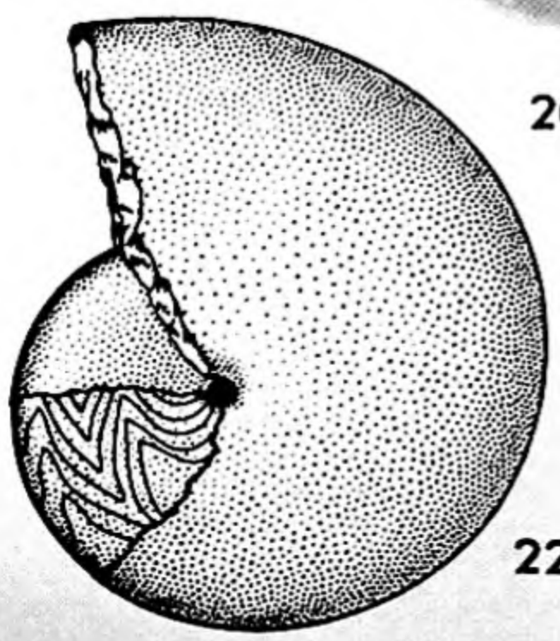

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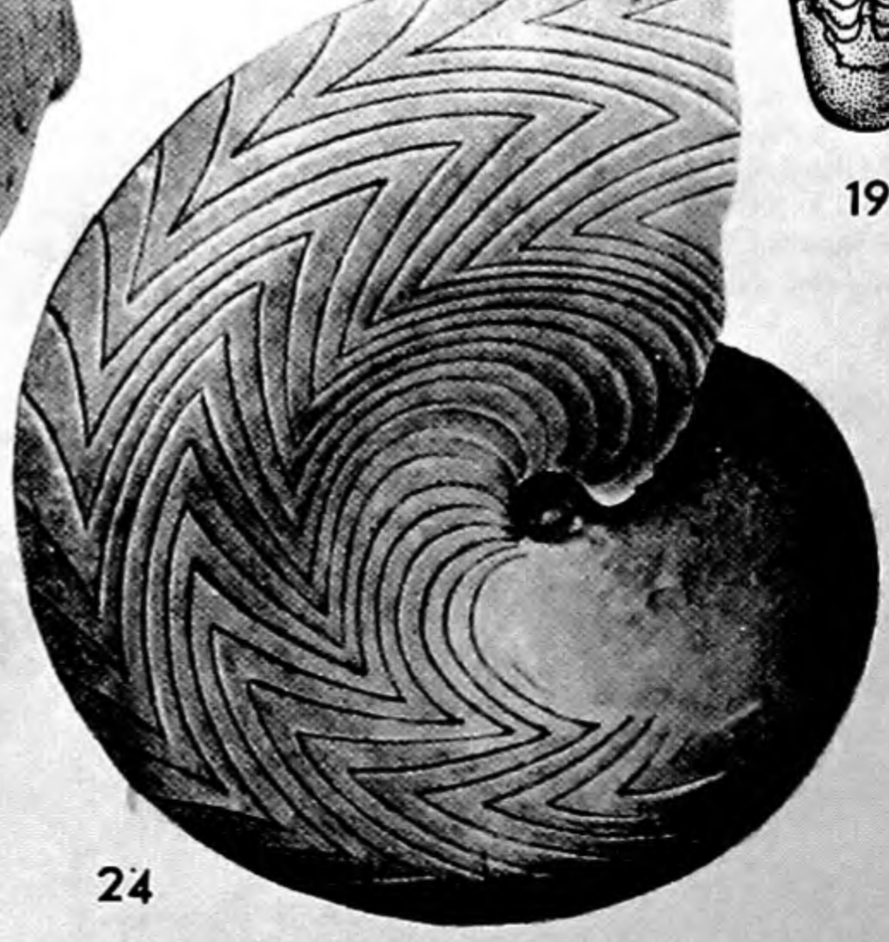

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Order Intrasiphonata. Conchs with siphuncle in dorsal position. **Dev.**

PLATYCLYMENIA Hyatt 1884

(**Clymenia annulata* Muenster). Conch ammoniticonic, subdiscoidal, widely umbilicate, ribbed or smooth; growth lines form a broad shallow sinus on lateral sides of conch, a rather prominent, narrowly rounded ventrolateral salient, and a similar ventral sinus; ribs if present parallel to growth lines; each mature suture forms a broad ventral saddle, a pair of broad, broadly rounded lateral lobes, a pair of narrow, narrowly rounded asymmetrical lateral saddles, which center on the umbilical seams, and a deep subangular, almost V-shaped dorsal lobe; siphuncle small, dorsal and marginal in position. **U. Dev.**

P. (Pleuroclymenia) americana (Raymond) (**231**—20). Conch almost subglobular, umbilicus relatively narrow, whorls low and broad; growth lines essentially straight on lateral side of conch, and forming broad, relatively shallow ventral sinuses. **U. Dev.:** Mont. (Three Forks); Alta?.

Order Extrasiphonata. Conchs with siphuncle in ventral position. **U. Sil.–Cret.**

BACTRITES Sandberger 1843

(**B. subconicus*). Conch long, straight, slender, circular or elliptical in section; aperture with hyponomic sinus on siphonal side of conch; at maturity each suture forms a small, prominent, V-shaped ventral lobe; lateral and dorsal portions of sutures essentially straight or with shallow lateral lobes and dorsal saddle; septa directly transverse to conch axis, or slightly oblique thereto; siphuncle ventral and marginal. **M. Dev.–Penn.** (see below for distribution; also Mo., Ark., Okla., Tex.).

B.? aciculum (Hall) (**231**—1, 2). **M. Dev.:** Beauvais of Mo.; Marcellus and its equivalents in Pa. and W. Va.; Hamilton of Pa.; **U. Dev.:** N. Y. (Naples); also reported, probably incorrectly according to Miller (1938, 32), from Onondaga and its equivalents in Pa., Md., Va., and W. Va.; Tully of N. Y.; Genesee and its equivalents in N. Y., Md., W. Va.; Naples and equivalents in N. Y., Pa., Va., W. Va., and Mackenzie Basin in northwestern Canada; Chemung of N. Y. and Pa.; **U. Dev.:** Alta. (U. Minnewanka).

B. arkonensis Whiteaves (**231**—3). **M. Dev.:** Ont. (Arkona); Ohio (Plumb Creek).

B. gracilior Clarke (**231**—4). **Dev.** (Genesee–Naples): N. Y. Possibly Chemung of N. Y. and Kiln of Alta.

LOBOBACTRITES Schindewolf 1932

(**Bactrites ellipticus* Frech). Like *Bactrites ss*, but with well developed lateral lobes in sutures. **M. Dev.**

L. clavus (Hall) (**231**—11). **Marcellus:** N. Y., Pa.

AGONIATITES Meek 1877

(**Goniatites vanuxemi* Hall). Conch ammoniticonic, subdiscoidal, deeply involute; each growth line forms a sinus on ventral and lateral sides of conch and salient on umbilical shoulders and ventrolateral zones; each mature suture forms small V-shaped ventral lobe and on each side of it a rounded or subangular ventrolateral saddle and broad, rounded or subangular lateral saddles; dorsal lobe broad, moderately shallow; siphuncle ventral and marginal; septal necks straight. **M. Dev.** (see below for distribution).

***A. vanuxemi** (Hall) (**231**—9, 10). **M. Dev.** (Marcellus): N. Y. (Cherry Valley), possibly Romney of N. Y. and Pa.; and Onondaga, Hamilton, and Canadaway of N. Y.; **M. Dev.** of Germany.

PROBELOCERAS Clarke 1899

(**Goniatites lutheri*). Conch less involute than *Manticoceras;* suture of young manticoceran, becoming sharply angular in adult; siphuncle small, ventral and almost marginal. **Dev.**

***P. lutheri** (Clarke) (**231**—5). **Genesee** and **Naples:** N. Y., Pa., Md., Va., W. Va.

MANTICOCERAS Hyatt 1884

(**Goniatites simulator* Hall). Conch ammoniticonic; growth lines biconvex, forming ventral and lateral sinuses and ventrolateral and dorsolateral salients; at maturity each complete suture forms a total of six primary lobes — a broad, unequally trifid but symmetrical ventral lobe, two pairs of lateral lobes, and a V-shaped dorsal lobe; saddles rounded; siphuncle small, ventral and marginal. **Dev.** (Senecan and Chautauquan of eastern Canada and U. S. A.).

***M. simulator** (Hall) (**231**—6–8). **Naples** and **Genesee** of N. Y.

M. sinuosum (Hall) (**231**—16, 17). **Dev.:** N. Y. (Naples, Chemung, Canadaway), Va. (Jennings); questionably Abitibi (U. Dev.) of James Bay region, and Hay River? of Great Slave Lake.

PLATE 234

[Figures are x1 and after Hyatt [USGS, M 42] unless otherwise indicated; original drawings furnished by Miller and Furnish are indicated by M and F.]

1–3. Girtyoceras limatum [JP 14]. Three views of holotype. **4, 5. Goniatites crenistria.** Small portion of surface enlarged, and lateral view of early adult specimen (x1.5). **6–8. Neoglyphioceras subcirculare** (x2). Septum, and two views of a specimen. **9, 10. Goniatites kentuckiensis** [JP 14]. **11, 12. Owenoceras bellilineatum** (x2) [JP 13]. **13–17. Lyrogoniatites** spp. **13, 14. L. newsomi.** Inner coil of a specimen (x3). **15–17. L. newsomi georgiensis** [JP 14]. Three views of the holotype (x1.5). **18, 19. Imitoceras grahamense** (x1.5) [M and F]. **20, 21. Anthracoceras missouriense** (x2) [JP 13]. **22–25. Goniloboceras** spp. **22, 23. G. welleri** [M and F]. **24, 25. G. goniolobum.**

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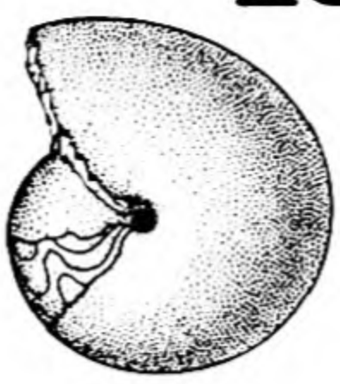

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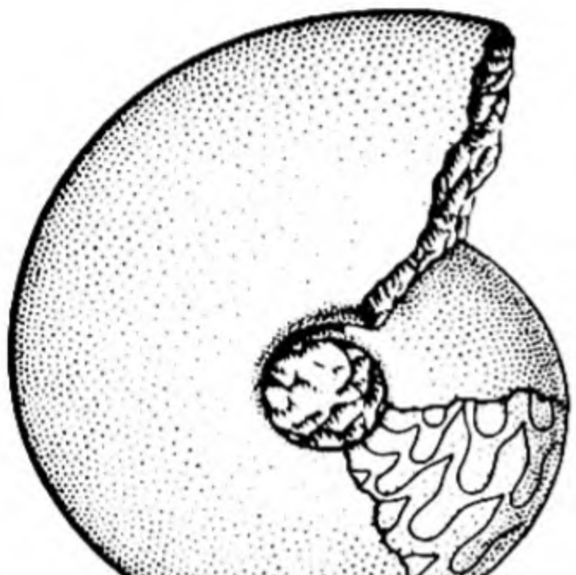

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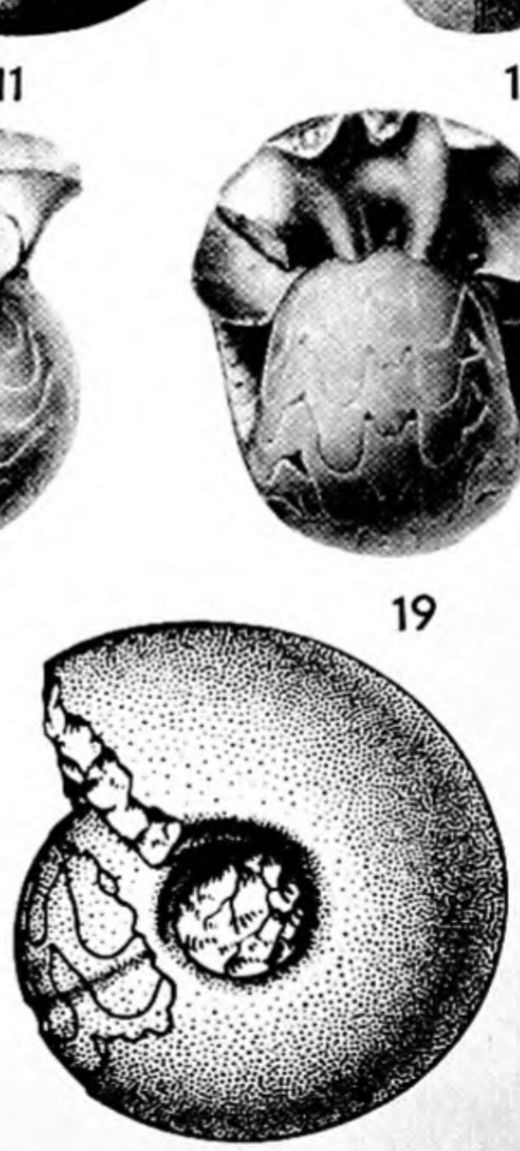

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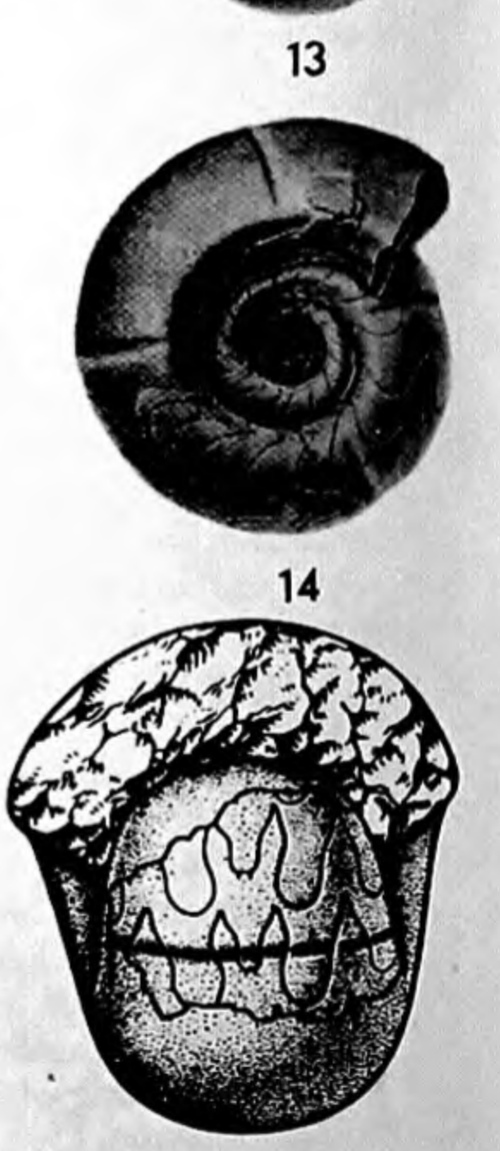

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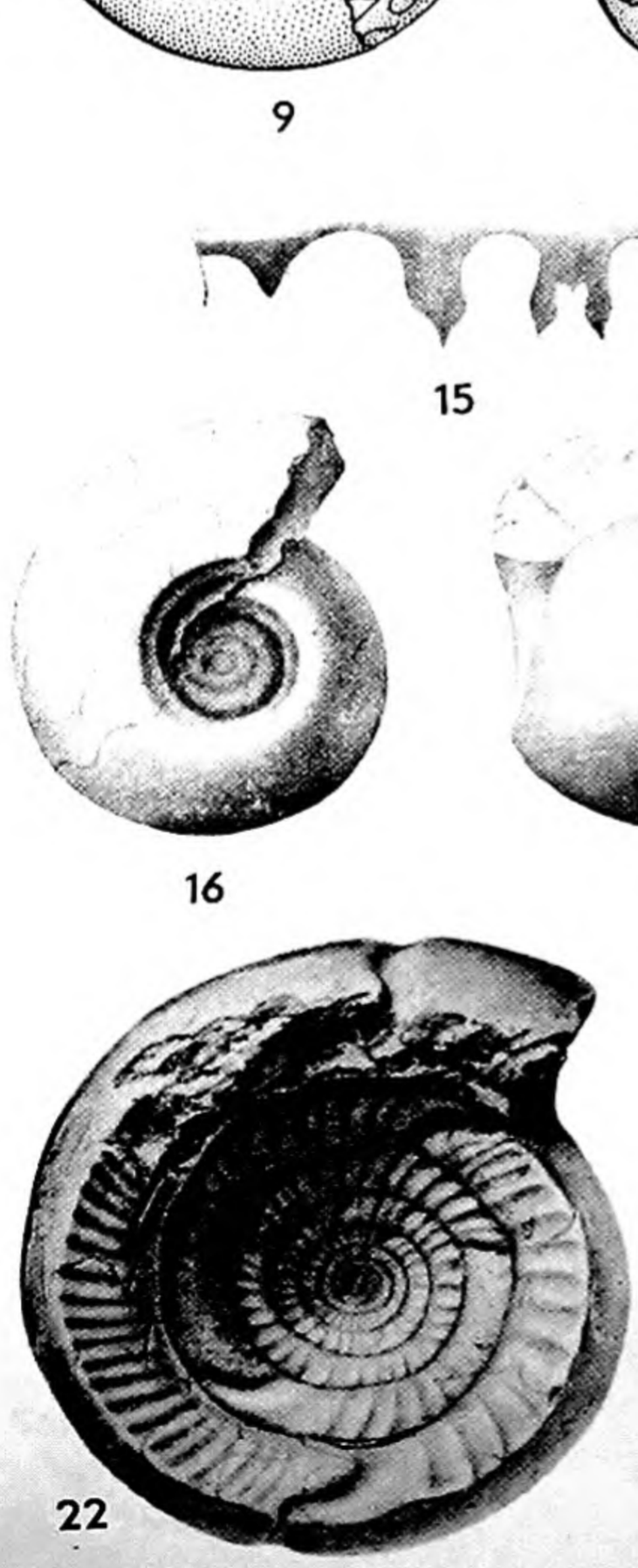

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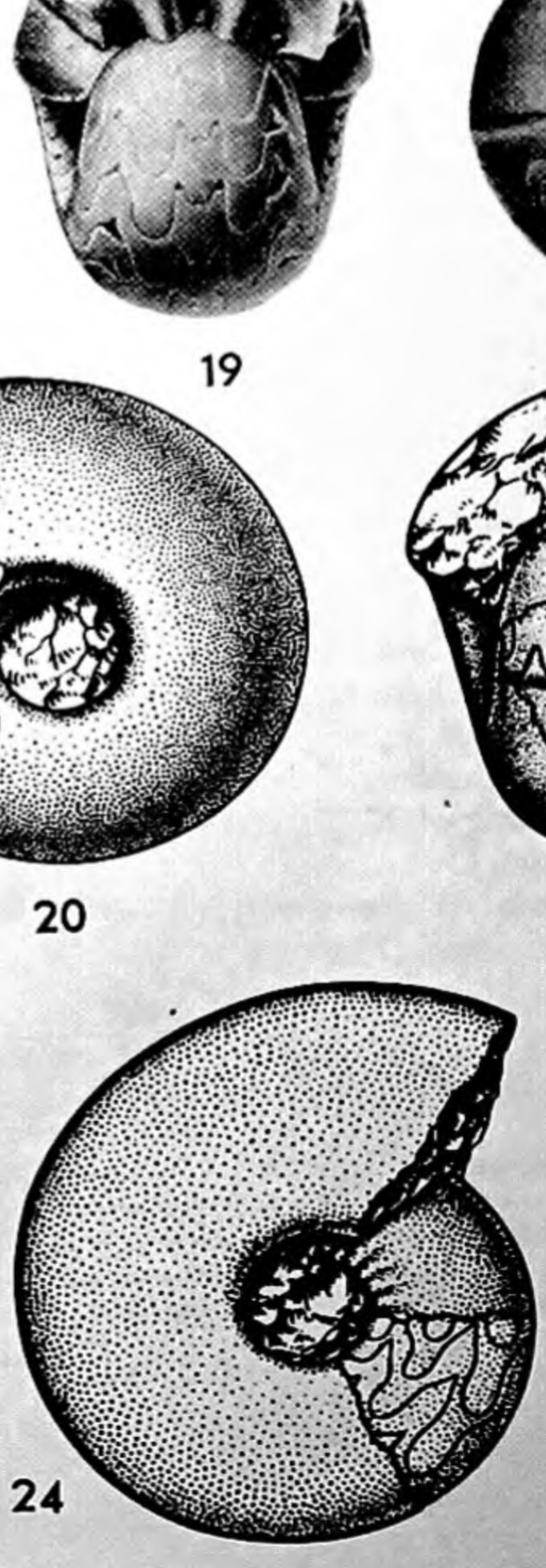

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TORNOCERAS Hyatt 1884

(**Goniatites uniangularis* Conrad). Conch ammoniticonic, subdiscoidal or sublenticular; whorls compressed, flattened laterally, impressed dorsally, and rounded, subangular or flattened ventrally; umbilicus closed, or open and funnel-shaped; growth lines sinuous, forming sinuses on ventral and lateral sides of conch, and salients on ventrolateral and dorsolateral sides; at maturity each external suture forms a small V-shaped ventral lobe, and on each side of it a ventrolateral saddle, a lateral rounded adventitious lobe, a broad lateral saddle, and a first lateral lobe on umbilical portion of conch; internal suture has dorsal lobe, on each side of which is a broad saddle extending to lobe on umbilical wall; siphuncle small, ventral and marginal; septal necks retrosiphonate. **Dev.** (see below for distribution).

***T. (Tornoceras) uniangulare** (Conrad) (**231**—12, 13). **Dev.:** Hamilton of N. Y. (Moscow); Marcellus and equivalents in N. Y. and Va.; Hamilton and equivalents in Ont.; N. Y.; Va., and Ohio; Tully of N. Y. and ?Pa.; Genesee and equivalents in N. Y., Md., and W. Va.; Naples and equivalents in N. Y., Md., and Va.; Antrim of Mich.; **U. Dev.** of Ia.

T. (Paradoceras) discoideum (Hall) (**231**—14, 15). **Marcellus:** N. Y.

SPORADOCERAS Hyatt 1884

(**Goniatites bidens* Sandberger and Sandberger). Generic characteristics shown in part by illustration of species. The genus is widespread in the Eastern Hemisphere, occurring in Europe, Asia, Africa, and Australia, but only one species is known from America. **Dev.**

S. milleri (Flower and Caster) (**232**—5–7). **Dev.:** Pa. (Conewango).

PROTOCANITES Schmidt 1923

(**Goniatites lyoni* Meek and Worthen). Conch with whorls compressed, impressed dorsally, rounded ventrally; umbilicus large, open; umbilical shoulders rounded. **Miss.**

***P. lyoni** (M and W) (**231**—21–23). **L. and M. Miss.:** Va. (Price), Ohio (Cuyahoga), Ind. (Rockford), Mo. (Chouteau).

PROLECANITES Mojsisovics 1882

(**P. mojsisovics* Miller). Evolute, compressed goniatites with wide umbilicus, slightly embracing whorls and lanceolate septa; a ventral lobe, four pairs of external lobes, a dorsal lobe, and one pair of internal lateral lobes. **Dev.–M. Penn.**

P. greeni (Miller) (**231**—18, 19). **L. Miss.:** Ind. (Kinderhook).

PRODROMITES Smith and Weller 1901

(**Goniatites gorbyi* Miller). Laterally compressed, discoidal and involute, with deeply embracing whorls, narrow unbilicus, high, hollow abdominal keel and complex ceratitic sutures, with numerous rounded saddles and notched lobes; ventral lobe long and undivided. **Miss.** (see below for distribution).

***P. gorbyi** (Miller) (**232**—10, 11). **L. Miss.:** Ind. (Rockford), Ia. (Kinderhook), Mo. (Chouteau).

PRONORITES Mojsisovics 1882

(**Goniatites cyclolobus* Phillips). Discoidal, with high, narrow whorls, nearly parallel sides, very involute, and with narrow umbilicus; siphonal lobe three-pointed; first lateral lobe divided into two to three parts by secondary sinuses; three to six auxiliary lateral lobes, all slightly pointed; saddles all rounded. **L.** and **M. Penn.** (Ark., Kan., Tex.; Russia).

P. arkansasensis Smith (**232**—1, 2). **Penn.:** Ark. (Hale), Tex. (Bend).

UDDENITES Boese 1917

(**U. schucherti*). Furrowed venter; keels in some species slightly beaded; flat, nearly parallel flanks; no secondary lobes on sides of ventral lobe; only first lateral lobe divided. **U. Penn.** (widespread throughout Tex.).

***U. schucherti** Boese (**232**—3, 4). **Graham** (Cisco) and **Gaptank** of Tex. (best known ammonite zone in north-central Texas).

PROUDDENITES Miller 1930

(**P. primus*). Venter without furrow; first lateral lobe large and divided into three elements; other laterals undivided. **U. Penn.** (Kansas City of Mo. and Okla.; Gaptank and Graford of Tex.; Urals).

***P. primus** Miller (**232**—12, 13). **U. Penn.:** Okla. (Nellie Bly). (Varieties of this species have been reported from widely separated areas in the Mid-continent states.)

PROPINACOCERAS Gemmellaro 1887

(**P. beyrichi*). Furrowed venter bordered by beaded keels; ventral lobe bifid; first lateral divided by four notches; other principal lateral lobes bifid. **M. Penn.–Perm.** (Tex.; Coahuila; B. C.; **M. Perm.** of Sicily,

PLATE 235

[Figures are x1 and original by Miller and Furnish unless otherwise indicated.]

1, 2. Gastrioceras listeri. 3, 4. Bisatoceras primum. 5. Pseudoparalegoceras brazoense [U Tex B 3701]. Complete suture. **6–8. Gastrioceras branneri** [USGS, M 42]. Two views of a specimen, and suture of an adult (x2). **9–12. Schistoceras** spp. **9, 10. S. missouriense. 11, 12. S. hildrethi** [USGS, M 42]. **13–21. Eoasianites** spp. **13, 14. E. welleri** [JP 13]. **15–17. E. globulosus** [USGS, M 42]. Suture and two views of a specimen. **18, 19. E. ruzencevi** (x2) [GSA, SP 26]. Two views of the holotype. **20, 21. E. angulatus. 22, 23. Metalegoceras schucherti** (x2) [GSA, SP 26]. Two views of the holotype. **24, 25. Paralegoceras lowense.**

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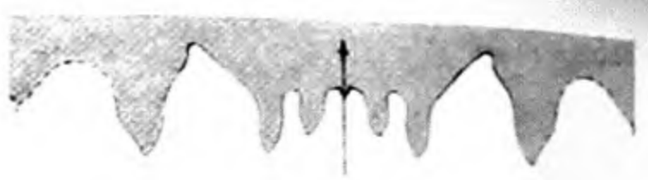

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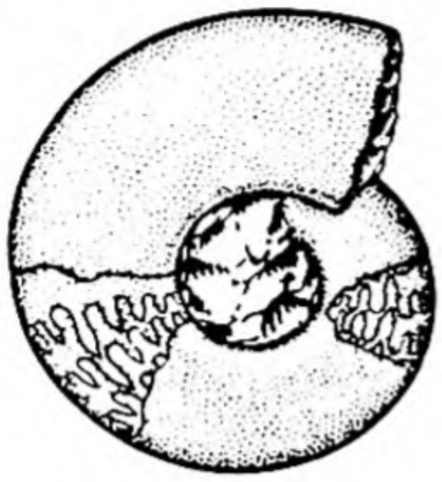

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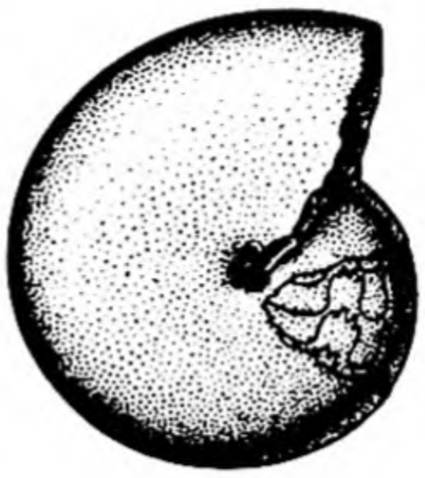

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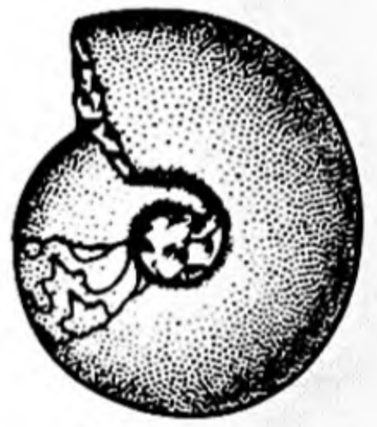

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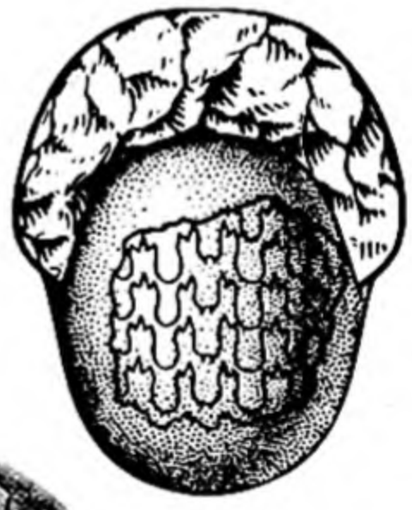

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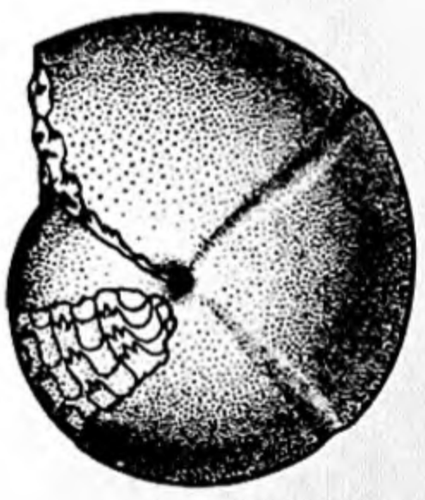

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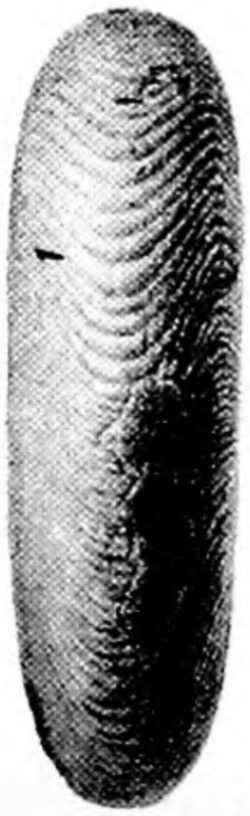

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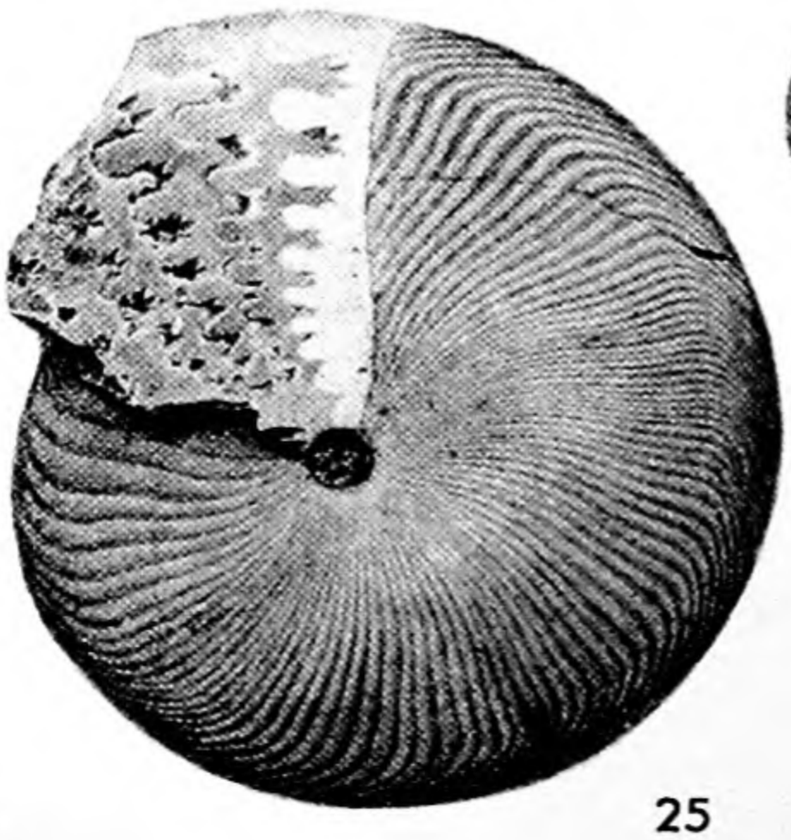

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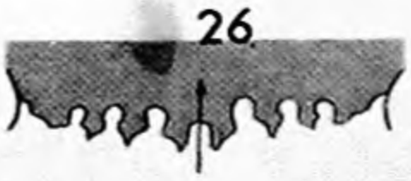

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Croatia, Crimea, the Pamirs, Darwaz; possibly **U. Perm.** of Mexico, Madagascar, and Timor).

P. knighti Miller and Furnish (**232**—8, 9). **Perm.:** Tex. (Bone Spring, Leonard, Blaine).

ARTINSKIA Karpinsky 1926

(**Goniatites falx* Eichwald = *Goniatites artiensis* Gruenewaldt). Furrowed venter bordered by beaded keels; ventral lobe trifid; first lateral lobe phylloid, others bifid. **Perm.** (worldwide distribution; Kan., Tex.).

A. huecoensis Miller and Furnish (**232**—14, 15). **Hueco:** Tex.

A. whortani Miller and Furnish (**232**—16, 17). **Penn.:** Northern Midcontinent.

MEDLICOTTIA Waagen 1880

(**Goniatites orbignyana* Verneuil). Furrowed venter with smooth, unnotched keels and smooth flanks which are flat near the umbilicus and slope toward the periphery; ventral lobe has two to four secondary elements; lateral lobes rounded and unnotched. **Perm.** (Greenland (Martinian); Tex. (Wichita, Clear Fork, Double Mountain, Leonard, Wood, and Delaware Mountain); Mexico (Leonard and Wood of Coahuila); India; Timor; The Pamirs; Urals; Novaya Zemlya; Crimea; Sicily).

M. whitneyi Boese (**233**—8, 9). **Perm.:** Tex. (Leonard and Hess in Glass Mountains, Blaine); Coahuila (Leonard).

DARAELITES Gemmellaro 1888

(**D. meeki*). A trifid ventral lobe and more than four pairs of external lateral lobes; the first and in most species the second lateral lobes are serrate; *Boesites* includes Pennsylvanian forms; *Daraelites*, Permian forms; the two vary only in nature of suture. **Perm.** (Tex.; Sicily; Urals; Timor).

BOESITES Miller and Furnish 1940

(**Daraelites texanus* Boese). Conch thinly subdiscoidal; umbilicus open and moderately large; sutures form a broad trifid ventral lobe, a broad first lateral lobe, and several smaller external lateral lobes; first lateral lobe is finely denticulate, second lateral lobe and lateral subdivisions of ventral lobe may be incipiently so. **Penn.** (Okla., Tex.).

***B. texanus** (Boese) (**233**—6, 7). **Penn.:** Okla. (Nellie Bly), Tex. (Gaptank, Graham).

PARACELTITES Gemmellaro 1887

(**P. hoeferi*). Evolute, laterally compressed, widely umbilicate, strongly ribbed; lateral ribs do not cross venter; suture characterized by one short, insignificant ventral saddle, two simple rounded lateral lobes. **Perm.** (Word, Capitan; Bone Spring, and Delaware Mountain of Texas; Coahuila; Sicily; Carnic Alps and Crimea; possibly Permian of British Columbia; China; Urals; Pyrenees).

P. ornatus Miller and Furnish (**233**—1, 2). **Word** of Tex. and Coahuila.

XENODISCITES Miller and Furnish 1940

(**X. waageni.*) Closely related to *Xenaspis*, differing in nature of suture. **Perm.**

***X. waageni** M and F (**233**—10). **Perm.:** Tex. (Capitan); Coahuila (Las Delicias).

XENASPIS Waagen 1895

(**Ceratites carbonarius*). Long living chamber; whorl evolute, little embracing; umbilicus wide, shallow; septa ceratitic, lobes and saddles short, two laterals longer than the external; internal septa consist of a short, bifid antisiphonal lobe, flanked by a lateral on the umbilical stuture, which might be considered as an auxiliary lobe. **Perm., Trias.** (Meekoceras beds of Cal.; **U. Perm.** of Salt Range and Himalayas, India; **M. Trias.** of eastern Siberia and India).

X. skinneri Miller and Furnish (**233**—11, 12). **Perm.:** Guadalupe Mountains, Tex.

X. marcoui Hyatt and Smith (**233**—3–5). **L. Trias.:** Cal.

XENODISCUS Waagen 1879

(**X. plicatus*). Evolute, discoidal, little embracing, increasing slowly in height, widely umbilicate, laterally compressed; body chamber not long; lateral sculpture strong, even on inner whorls, consisting of strong folds running from umbilicus up the sides; venter abruptly rounded; septa ceratitic, lobes and saddles short. **L. Trias.** (western U. S. A. and Canada).

X. waageni (Hyatt and Smith) (**233**—13–15). **Trias.** (Meekoceras zone): Idaho, Cal.

OPHICERAS Griesbach 1880

(**O. tibeticum*). Evolute, little embracing, whorls

PLATE 236

Figures are x1 and after Miller and Furnish [GSA, SP 26] unless otherwise indicated; original drawings furnished by Miller and Furnish are indicated by M and F.]

1, 2. Pseudogastrioceras altudense (x2). **3, 4. Dimorphoceras politum** (x2) [JP 13]. Two views of the neoholotype. **5, 6. Neodimorphoceras texanum** [U Tex B 3701]. Suture (x0.7), and lateral view of a partly restored specimen. **7, 8. Wellerites mohri** [M and F]. **9, 10. Eothaloceras kingorum** [M and F]. **11. Adrianites adamsi.** Lateral view of holotype. **12, 13. Agathiceras freschi** [U Tex B 3701]. Suture (x2.5), and lateral view of another specimen (x6). **14, 15. Neoshumardites** sp. [M and F]. **16–19. Shumardites simondsi.** Ventral view of type; suture showing mature characters (x1.6); ventral and lateral views of partly restored specimen. **20–22. Peritrochia** spp. **20, 21. P. ganti** [M and F]. **22. P. erebus** (x3). **23. Stacheoceras rothi.** Lateral view of incomplete specimen. **24, 25. Popanoceras bowmani** (x1.5). **26–29. Properrinites böseI** [U Tex B 3701]. 26: Internal suture at diameter of 11.5 mm. 27: External suture (x3) of a small individual at diameter of 11 mm. 28, 29: Lateral and ventral views of holotype.

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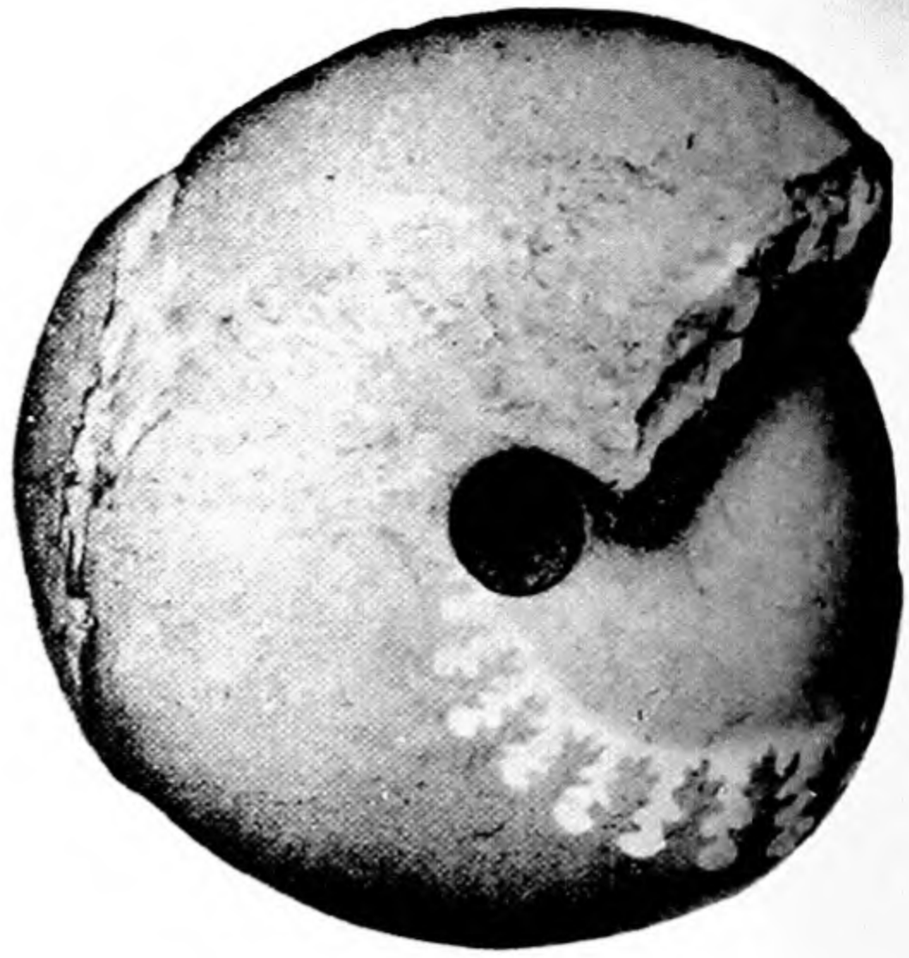

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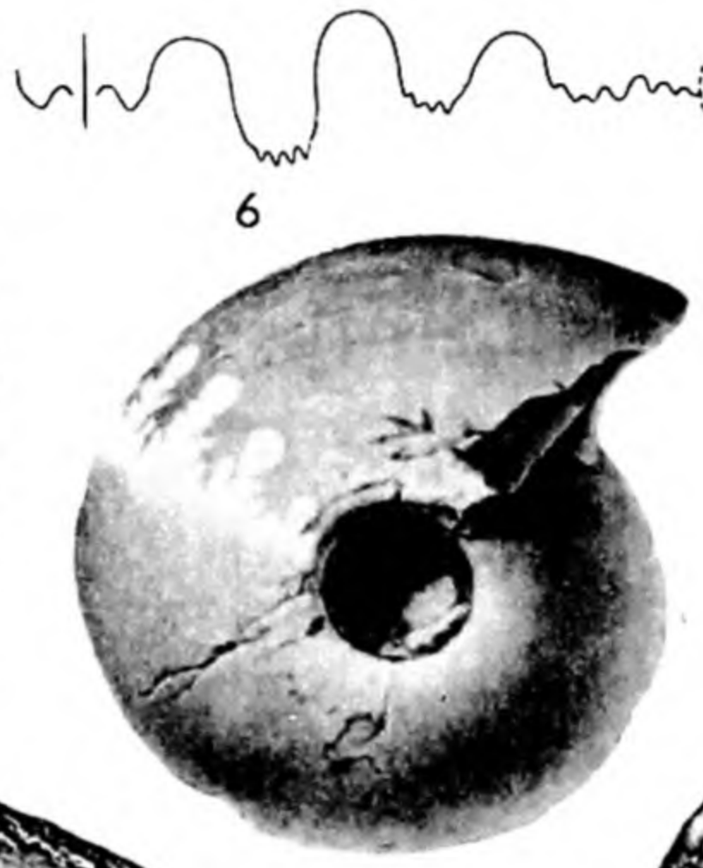

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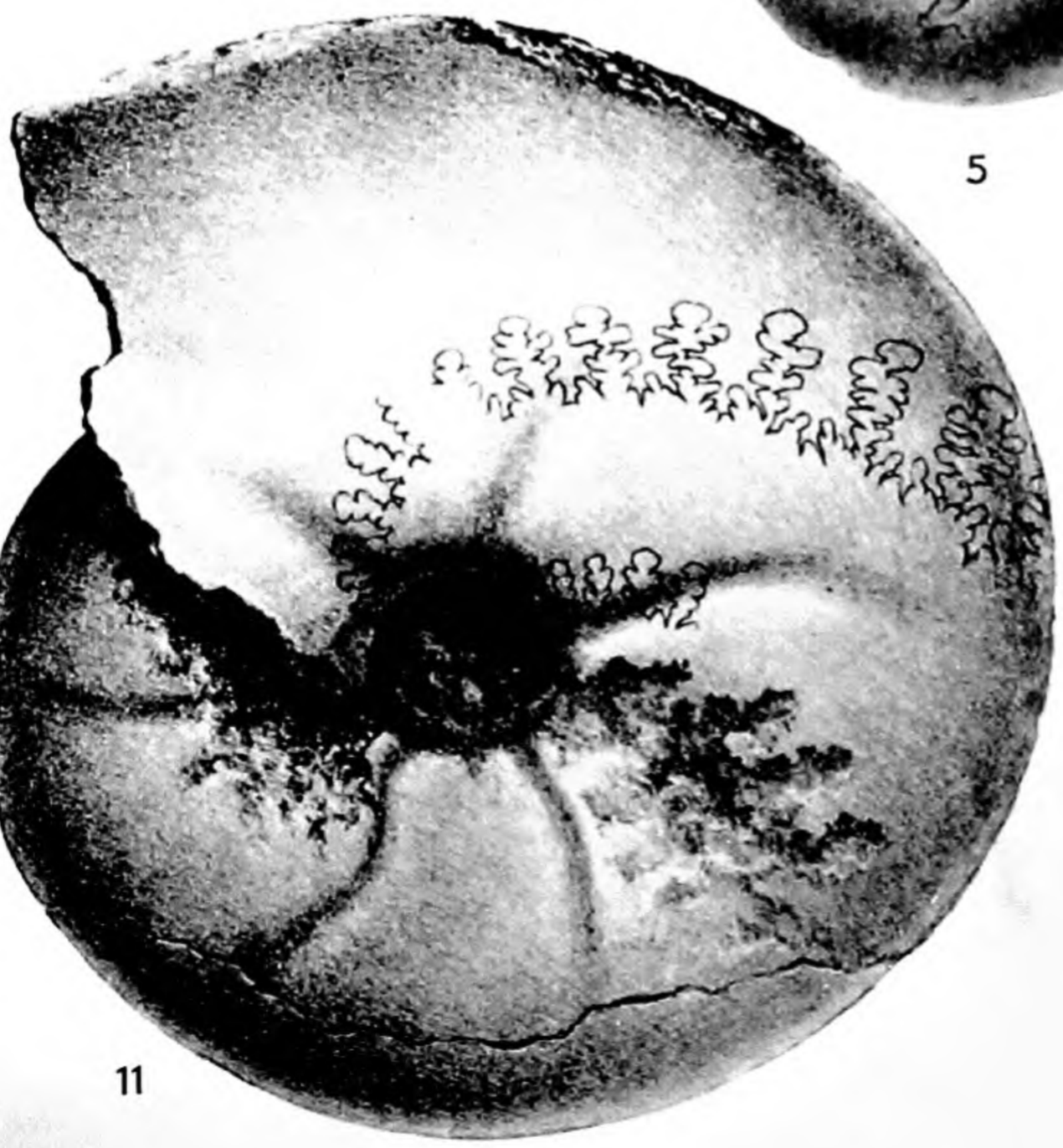

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increasing slowly in height; umbilicus wide, moderately deep; surface with faint folds and cross striae, and with coarse lateral ribs in old age; inner fillings with delicate spiral striation; septa ceratitic, lobes usually long and narrow. **L. Trias.** (Greenland: Idaho, Utah, Nev., Cal.; India.; Sibéria; Albania).

O. subquadratum Smith (**233**—21–23). **L. Trias.:** Meekoceras zone in Nev. and Cal.

MUNSTEROCERAS Hyatt 1884

(**Goniatites oweni parallela* Hall). Evolute, compressed or discoidal goniatites with highly arched whorls and moderately wide umbilicus; sutures with angular, superior, lateral lobe and acute second lateral lobe outside umbilicus; ventral lobe narrow with small notched saddle; surface smooth. **Miss.** (Mich., Ind., Mo.).

***M. parallelum** (Hall) (**233**—19, 20). **Kinderhook:** Mich. (Marshall), Ind. (Rockford).

EUMORPHOCERAS Girty 1909

(**E. bisulcatum*). Sides sculptured by two sulci (lateral grooves); larval stages have nodose umbilical shoulders; later stages have only plications which disappear before reaching sulcus; compressed. **U. Miss.** (southwestern U. S. A.).

E. bisulcatum Girty (**233**—16–18). **U. Miss.:** Okla. (Caney), Tex. (Barnett).

GIRTYOCERAS Wedekind 1918

(**Adelphoceras meslerianum* Girty). Closely related to *Eumorphoceras*, which, however, has a flattened venter, prominent lateral ribs, and longitudinal ventrolateral grooves — features absent in typical *Girtyoceras*, though there is more or less gradation between these two genera; also related to *Glyphioceras* and *Goniolobocera*s. **Miss.** (Ky., Ga. (Floyd), Okla. (Caney) and Tex. (Barnett, Helms); England; continental Europe).

G. limatum (Miller and Faber) (**234**—1–3). Differs from ***G. meslerianum** (Girty) in having slight ventrolateral grooves and more numerous transverse constrictions. **Miss.:** Ky., ?Ark. (Moorefield).

GONIATITES Haan 1825

(= GLYPHIOCERAS Hyatt 1884)

(**Conchyliolithus Nautilus sphaericus* Martin). Globose, with small umbilicus and reticulate sculpture on venter; angular lateral saddles. **Miss.** (N. America), **U. Viséan** (Europe).

G. crenistria Phillips (**234**—4, 5). **Miss.:** Ark. (Moorefield, Fayetteville), Okla., Tex. (Bend); Europe.

G. kentuckiensis Miller (**234**—9, 10). **Miss.** (St. Louis): Ky.

NEOGLYPHIOCERAS Bruening 1923

(**Goniatites spiralis* Phillips). External suture has wide ventral lobe indented by short ventral saddle; a bell-shaped, acute, first lateral saddle, a pointed lateral lobe, and a knee-shaped second lateral saddle. **Miss. Penn.** (Mo., Ark., Okla., Tex.; England; Europe; Africa).

N. subcirculare (Miller) (**234**—6–8). **Miss.:** Ky. (St. Louis), Ark. (Batesville), Okla. (Caney), Tex. (Barnett); Ireland; England; Belgium; Germany; France; Morocco; Algeria.

LYROGONIATITES Miller and Furnish 1940

(**L. newsomi georgiensis*). Similar to *Neoglyphioceras*, but differs particularly in that conch is subglobular rather than subdiscoidal and umbilicus is relatively large. **Miss.** (Midcontinent region).

***L. newsomi georgiensis** M and F (**234**—15–17). **Miss.:** Ga.

L. newsomi (Smith) (**234**—13, 14). **U. Miss.:** Ark. (Moorefield), Okla. (Caney), Tex. (Barnett, Helms); Europe (U. Viséan).

OWENOCERAS Miller and Furnish 1940

(**Neoglyphioceras bellilineatum* Miller and Owen). Similar to *Neoglyphioceras*, but has a gastrioceratid rather than a goniatitid type of suture and may not be closely related. **Penn.**

***O. bellilineatum** (M and O) (**234**—11, 12). **Cherokee:** Mo.

ANTHRACOCERAS Frech 1899

(**Nomismoceras* (*Anthracoceras*) *discus*). Compressed whorls, small umbilicus; noncrenulate with transverse striae; rounded lateral lobes; like *Dimorphoceras* but lacking the subsidiary saddles of the suture lines. **Penn.** (Ill., Mo., Okla., Tex.).

A. missouriense Miller and Owen (**234**—20, 21). **Cherokee:** Mo.

GONIOLOBOCERAS Hyatt 1900

(**Goniatites goniolobus* Meek). Large; large angular first lateral lobe and saddle; smooth or nearly smooth venter. **Penn.** (Ill., Mo., Kan., Okla., Tex., N. Mex.).

***G. goniolobum** (Meek) (**234**—24, 25). **Penn.:** Mo. (Kansas City), Kan. (Drum, Westerville), Tex. (Wayland, Cisco); **U. Penn.:** N. Mex.

PLATE 237

[Figures are x1 and after Miller and Furnish [GSA, SP 26] unless otherwise indicated.]

1. Perrinites hilli hilli (x1.5). **2, 3. Timorites uddeni.** Two views of holotype. **4, 5. Waagenoceras guadalupense guadalupense** (x1.5). **6–8. Clypeoceras pusillum** [USGS, PP 167]. Suture (x4), and two views of a specimen (x1.5). **9, 10. Meekoceras gracilitatis** [USGS, PP 167]. Lateral and apertural views showing radial folds. **11, 12. Cyclolobus oldhami** [Pal Indica, Mem G S 13].

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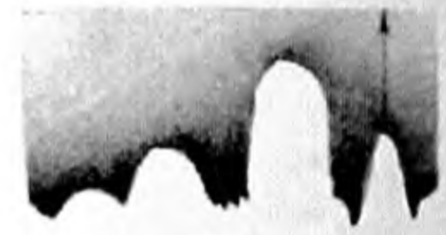

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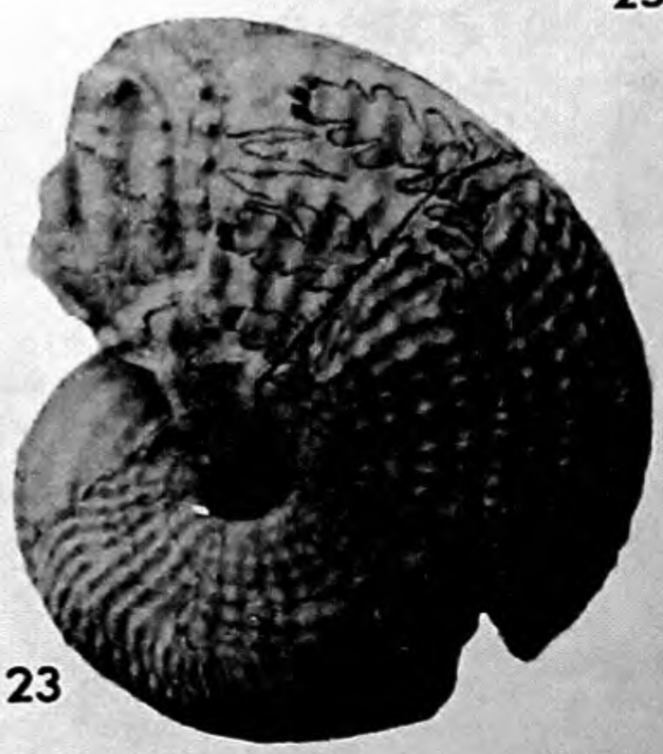

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G. welleri Smith (**234**—22, 23). Occurs with preceding.

IMITOCERAS Schindewolf 1924

(**Goniatites rotatorius* Koninck). Conch sublenticular; umbilicus small; sutures simple, forming only eight lobes, all of which are undivided. **U. Dev.** (Europe; Africa); **Miss.** (N. America; Europe; Africa); **Penn.** (N. America); **M. Perm.** (Sicily).

I. grahamense Miller and Furnish (**234**—18, 19). **Penn.:** Midcontinent region.

GASTRIOCERAS Hyatt 1884

(**Ammonites listeri* Martin). Involute, subglobose to globose ammonoids with lunar whorl cross-section, wide umbilicus, and pronounced sculptured surface, at least in some stages of growth; umbilical shoulders transversely ridged; suture consists of eight lobes and eight saddles. **Miss.–Perm.** (widespread throughout U. S. A.).

***G. listeri** (Martin) (**235**—1, 2). **L. Penn.:** Ark. (Atoka), Tex. (Smithwick); **L. Coal Measures** of England; **Westphalian** of Germany.

G. branneri Smith (**235**—6–8). **Chester:** Ark. **L. Penn.:** Ark., Okla.

PSEUDOPARALEGOCERAS Miller 1934

(**Gastrioceras russiense* Tzwetaev). Ammonoids with highly arched venter and wide umbilicus; like *Gastrioceras* but with five primary external lobes, three internal lobes, and no lobes on umbilical walls. **Penn.** (Midcontinent; Peru; Russia; northwestern Africa).

P. brazoense Plummer and Scott (**235**—5). **Penn.:** Okla. (Boggy), Tex. (Millsap Lake), N. Mex. (Magdalena).

BISATOCERAS Miller and Owen 1937

(**B. primum*). Conch thickly sublenticular; umbilicus small; sutures form eight lobes, all but one of which are undivided; ventral lobe prominently bifid and its subdivisions are broad. **L. Penn.** (Mo., Okla.).

***B. primum** M and O (**235**—3, 4). **L. Penn.:** Mo., Okla.

SCHISTOCERAS Hyatt 1884

(**Goniatites missouriensis* Miller and Faber). Ammonoids with highly arched venter, wide umbilicus; suture with 12 lobes, 12 saddles, and a bottle-shaped central saddle; three lateral lobes on each flank. **Penn.** (Ill., Mo., Okla., Tex.).

***S. missouriense** (M and F) (**235**—9, 10). **Penn.:** Pa. (Brush Creek), Ohio (Cambridge), Ill. (McLæansboro), Mo. (Kansas City), Okla. (Belle City), Tex. (Graford, Graham, Gaptank, Wichita).

S. hildrethi (Morton) (**235**—11, 12). Essentially same range and distribution as preceding.

EOASIANITES Ruzhencev 1933

(= GLAPHYRITES Ruzhencev 1936; PRESHUMARDITES Plummer and Scott 1937)

(**E. subhanieli*). Globose shells with wide umbilicus; umbilical shoulders without tubercles or pronounced ridges; suture lines consist of eight principal lobes and eight principal saddles; ventral saddle moderately deep, lobes spatulate. **Penn., L. Perm.** (widespread in N. America and Eurasia).

E. globulosus (Meek and Worthen) (**235**—15–17). **Penn.:** Ill., Ark., Tex. (Cisco).

E. welleri (Smith) (**235**—13, 14). **Penn.:** Ill., Mo. (Cherokee), Kan. (Cherokee), Tex. (Millsap Lake).

E. angulatus Miller and Furnish (**235**—20, 21). **Penn.:** Northern Midcontinent region.

E. ruzencevi Miller and Furnish (**235**—18, 19). Possibly an involute variety of **E. modestus** (Boese), which is found at numerous points in Texas. **Perm.:** Tex. (Gaptank of Glass Mts. in Uddenites zone; Hueco).

PARALEGOCERAS Hyatt 1884

(**Goniatites iowensis* Meek and Worthen). Compressed, widely unbilicate ammonoids having 10 lobes, 10 saddles, and a bottle-shaped ventral saddle; two lateral lobes on each flank, one on each umbilical wall. **Penn., Perm.** (Ia., Tex.).

***P. iowense** (M and W) (**235**—24, 25). **Penn.:** Ia., Ark. (Atoka), Tex. (Smithwick).

METALEGOCERAS Schindewolf 1931

(**Paralegoceras sundaicum evoluta* Haniel). Globose shells; umbilical shoulders without pronounced sculpture; suture line consists of 10 lobes and 10 saddles. **L.** and **M. Perm.** (Tex.; Ural Region; Western Australia; Timor).

M. schucherti Miller and Furnish (**235**—22, 23). **Leonard:** Tex.

PSEUDOGASTRIOCERAS Spath 1930

(**Gastrioceras abichianum* Arthaber ≒ *Goniatites abichianus* Moeller = *Goniatites striatus* Abich, not

PLATE 238

[Figures are x1 and after Hyatt and Smith [USGS, PP 40] unless otherwise indicated.]

1–3. Anasibrites kingianus [USGS, PP 167]. Two views of a specimen, and suture (x2). **4–7. Cuccoceras bonae-vistae** [USGS, PP 83]. Three views of a well preserved shell, and suture (x2). **8–10. Tirolites (Metatirolites) foliaceus** [USGS, PP 141]. Two views of a specimen (x2), and suture of another (x4). **11–17. Ceratites** spp. **11–14. C. humboldtensis.** Three views, and suture (x2), of a specimen at beginning of maturity. **15–17. C. (Gymnotoceras) russelli.** Two views, and suture (x2), of adult specimens. **18–20. Acrochordiceras hyatti.** Suture, and two views of a specimen. **21–23. Trachyceras (Protrachyceras) shastense** [USGS. PP 141]. Suture and two views of the type. **24–26. Columbites parisianus.** Suture (x2), and two views of a specimen at early maturity.

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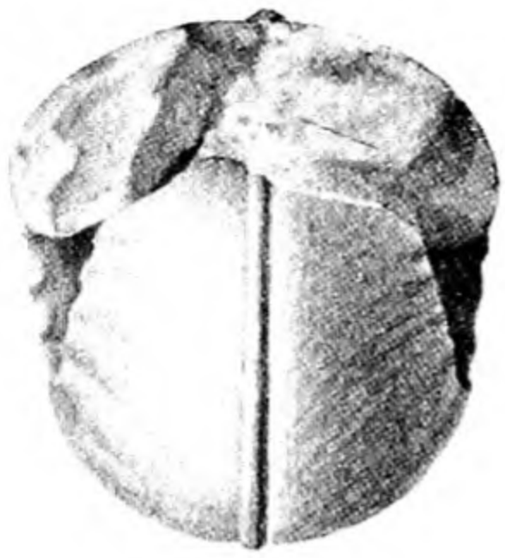

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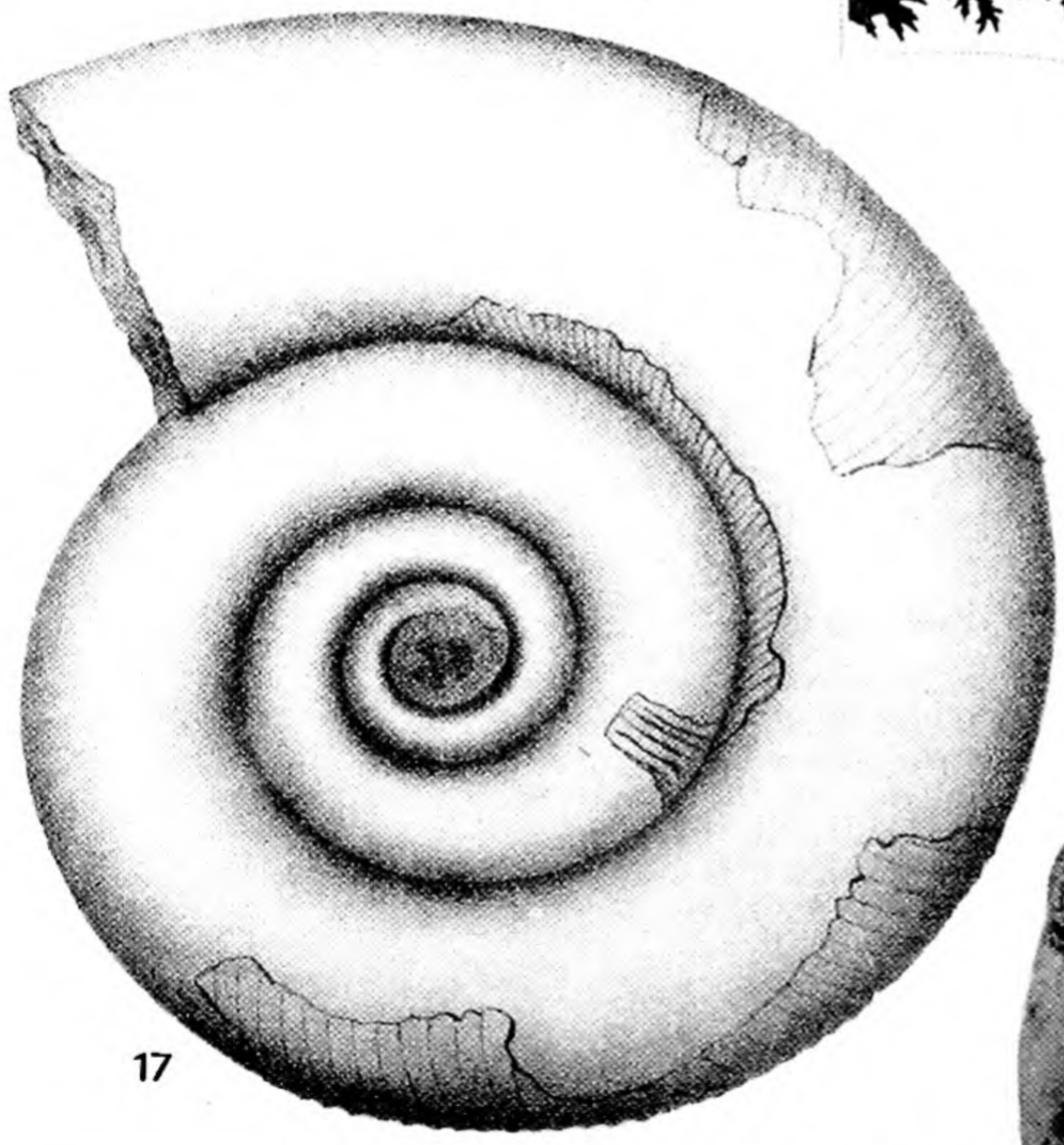

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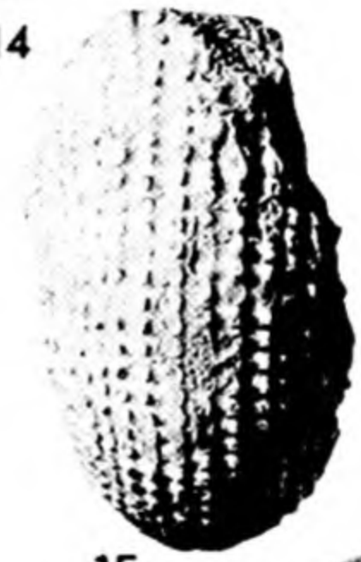

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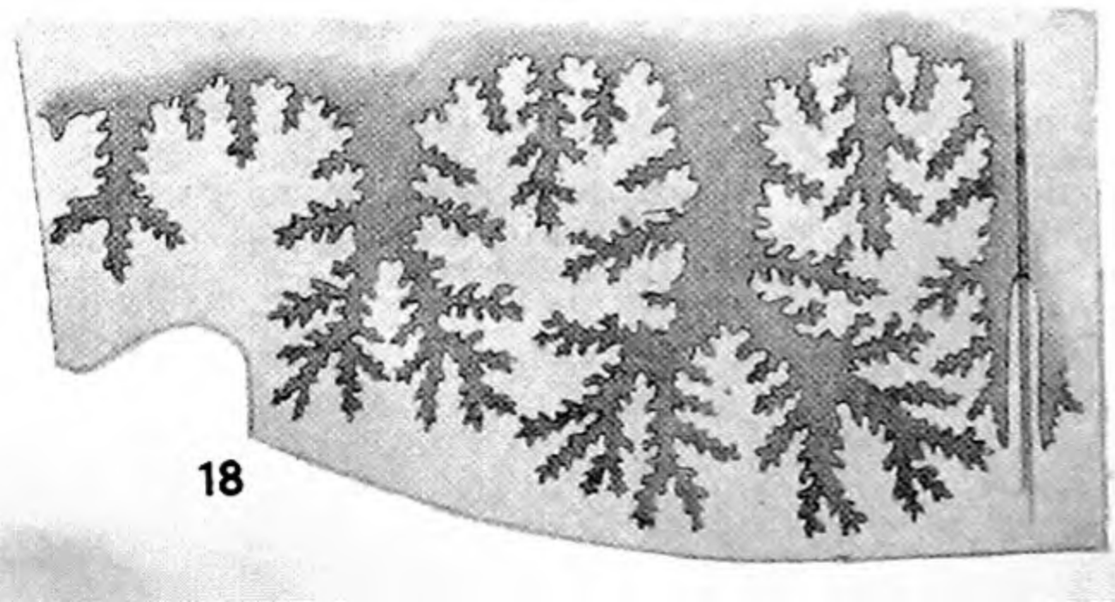

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Sowerby). Conch subglobular to subdiscoidal, rounded ventrally; surface longitudinally ribbed; umbilicus large or small, umbilical zones nodose at least in youth; sutures with eight lobes, only ventral one of which is divided; there is almost complete gradation from *Paragastrioceras* (which is not described in this work) through *Pseudogastrioceras* to *Strigogoniatites*, which differs from the genus just described in having at maturity venter angular, longitudinal ribs lost, and lateral grooves developed. **Perm.** (L. Perm. of north-central Tex. in Admiral; Urals; M. Perm. of west Tex. in Word, Capitan and Delaware Mountain; Coahuila in Word and Capitan equivalents; Wyoming in Phosphoria; Urals, Novaya Zemlya, Croatia?, Karakorum Mountains, China, Armenia).

P. altudense (Boese) (**236**—1, 2). Widespread in the **M. Perm.** of Tex.

DIMORPHOCERAS Hyatt 1884

(**Goniatites gilbertsoni* Phillips). Arched venter; secondary saddles less than half as long as ventral lobe; large principal first lateral saddle rounded. **Miss.–Penn.** (Ky., Ill., Mo., Tex.).

D. politum (Shumard) (**236**—3, 4). **Penn.:** Ill. (L. Penn.), Mo. (Cherokee), Tex. (Smithwick).

NEODIMORPHOCERAS Schmidt 1925

(**Dimorphoceras texanum* Smith). Arched venter with or without furrow; small secondary saddle two-thirds as long, or as long as, ventral saddle; large first lateral saddle angular. **Penn.** (widespread in Tex.).

***N. texanum** (Smith) (**236**—5, 6). **Graham** (Cisco): Tex.

WELLERITES Plummer and Scott 1937

(**W. mohri*). Conch thinly sublenticular; umbilicus open and moderately large; external sutures form small bifid ventral lobe and on each side of it about six pointed lobes, the first of which is small, the second large. **L. Penn.** (Okla., Tex.).

***W. mohri** P and S (**236**—7, 8). **L. Penn.:** Mid-continent.

EOTHALASSOCERAS Miller and Furnish 1940

(**Protothalassoceras inexpectans* Miller and Owen). Sides smooth, fairly flat, converging ventrally; venter rounded; small and nearly closed, steep-sided umbilicus; in suture line denticulation is restricted to base of external lobe. **M.** and **U. Penn.** (Okla., Tex.).

E. kingorum (Miller) (**236**—9, 10). **Gaptank, Graham:** Tex.

ADRIANITES Gemmellaro 1888

(**A. elegans*). Similar to *Agathiceras* but more highly developed; sutures with many lobes and saddles. **L. Perm.:** B. C. (Cache Creek); Tex. (Leonard, Wood); Coahuila (Las Delicias); **Perm.** (Sicily; Urals; Crimea; Pamirs; Timor; ?Croatia).

A. adamsi Miller and Furnish (**236**—11). **Word:** Tex.

AGATHICERAS Gemmellaro 1887

(**A. suessi*). Venter sculptured with strong longitudinal ribs; lateral lobes and saddles nearly equal in size and shape. **L. Penn., Perm.** (worldwide distribution; B. C.; Okla., Tex.; Coahuila).

A. frechi Boese (**236**—12, 13). **Tex.:** (Gaptank; Graham).

NEOSHUMARDITES Ruzhencev 1936

(**N. triceps*). Conch subglobular; umbilicus open and moderately large; sutures form eight lobes, five of which are undivided; ventral lobe is prominently bifid and external lateral lobes are trifid. **Penn., Perm.** (N. America; Europe).

Neoshumardites sp. (**236**—14, 15). **Penn.:** Mid-continent region.

SHUMARDITES Smith 1903

(**S. simondsi*). Medium-sized umbilicus; suture line characterized by pointed, trifid complex lateral lobes, rounded complex saddles, and a simple second lobe on flank or umbilical shoulder. **U. Penn.**

***S. simondsi** Smith (**236**—16–19). **Cisco, Gaptank:** Tex.

PERITROCHIA Girty 1908

(**P. erebus*). Conch subglobular, whorls depressed and broadly rounded ventrally, umbilicus small; living chamber one volution long; moderately conspicuous growth lines form shallow ventral and lateral sinuses; sutures form large bifid ventral lobe, several smaller lobes on flanks of conch, several narrow internal lateral lobes, and a deep dorsal lobe; gradational with *Stacheoceras*. **L. Penn.–M. Perm.** (Penn. of Kan., Okla., Tex.; Urals; L. Perm. of west Tex., in Wolfcamp and Hueco; of north-central Tex., in Admiral and Clyde; in Urals, Crimea, Timor; M. Perm. of west Tex., in Leonard and Bone Spring; in Urals, Timor, and possibly

PLATE 239

[Figures are x1 and after Smith [USGS, PP 141] unless otherwise indicated.]

1, 2. Tropites subbullatus. Two views of an adult specimen. **3. Arniotites vancouverensis.** Lateral view of type. **4–6. Discotropites sandlingensis** [USGS, PP 40]. Suture (x2), and two views of another specimen. **7, 8. Arcestes (Proarcestes) shastensis.** Two views of the type. **9–11. Juvavites (Anatomites) brockensis.** Suture (x2), and two views of the type. **12, 13. Pseudosageceras intermontanum** [USGS, PP 40]. Two views of the type specimen (x0.5). **14–16. Sagenites (Trachysagenites) herbichi** (x0.5) [USGS, PP 40]. Suture from an internal filling, and two views of a mature shell. **17, 18. Lytoceras batesi** [Pal Cal 1]. Lateral view and suture. **19. Phylloceras (Hypophylloceras) onoense** [GSA, SP 16].

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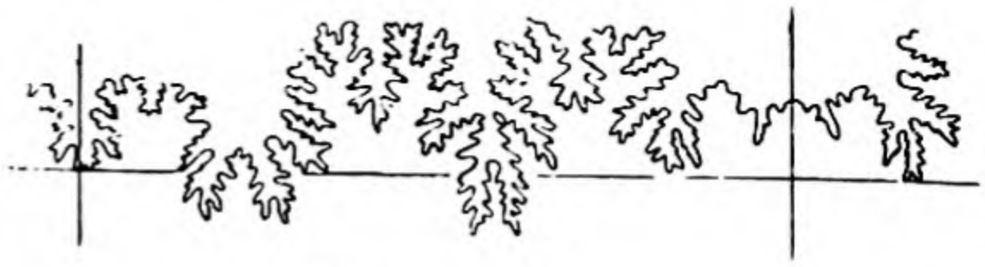

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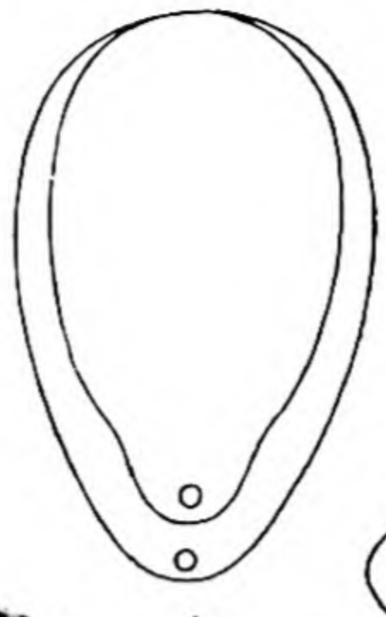

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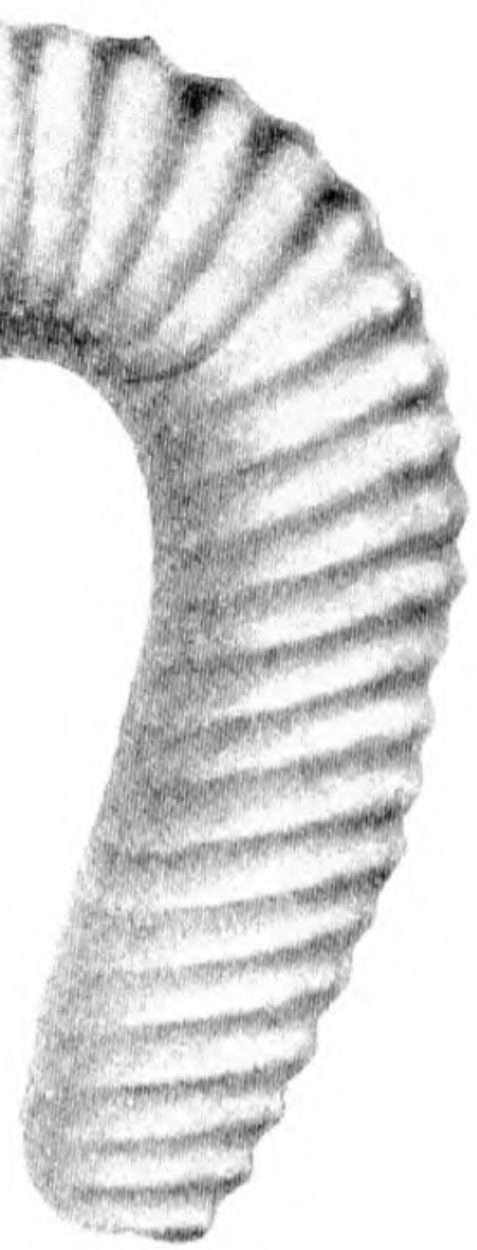

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the Pamirs; possible congeneric forms known from higher horizons in Wyo.; Sicily; Timor).

***P. erebus** Girty (**236**—22). **Bone Spring:** Tex.

P. ganti (Smith) (**236**—20, 21). **Gaptank:** Tex.

POPANOCERAS Hyatt 1884

(**Goniatites sobolewskyanus* Verneuil). Shell compressed; umbilicus very small; up to nine lobes and ten saddles in external suture; ventral lobe has two to six secondary lobes in each half; first lateral lobe has four to six secondaries. **L.** and **M. Perm.** (worldwide distribution).

P. bowmani (Boese) (**236**—24, 25). **Word:** Tex.

STACHEOCERAS Gemmellaro 1888

(**S. mediterraneum*). Conch subglobular to subdiscoidal; umbilicus small; growth lines form ventral and lateral sinuses; living chamber about one volution long; sutures form a bifid ventral lobe, several external lateral lobes, a subdivided umbilical lobe, several internal lateral lobes, and a trifid dorsal lobe; prongs of lobes digitate; lobes decrease in size and prominence in digitation from venter toward umbilicus. **Perm.** (worldwide distribution; in N. America, reported from Phosphoria of Wyo., Blaine and Leonard of Tex., Word and Capitan of Coahuila; possibly also from **Perm.** of Presidio County, Tex., and from Cal.).

S. rothi Miller and Furnish (**236**—23). **Leonard** (Hess): Tex.

PROPERRINITES Elias 1938

(**Perrinites boesei* Plummer and Scott). Intermediate between *Shumardites* and *Perrinites*. **L. Perm.:** Kan., Tex.

***P. boesei** (P and S) (**236**—26–29). **Admiral:** Tex.

PERRINITES Boese 1919

(**Waagenoceras hilli* Smith). Umbilicus small; suture characterized by lateral lobes with many secondary elements. **M. Perm.** (Tex.; Mexico; the Pamirs, U. S. S. R.).

***P. hilli** (Smith). "Form genus and species" including all of the North American "species" so far referred to *Perrinites*; several varieties are recognizable. **P. hilli hilli** (Smith) (**237**—1), which is typical *P. hilli*, has three digits on ventral side of prongs of ventral lobe, the adoral two of which may be bifid. **Leonard:** Tex.

WAAGENOCERAS Gemmellaro 1887

(**W. mojsisovicsi*). Lobes and saddles strongly divided. **M.** and **U. Perm.** (west Tex.; Coahuila; Sicily; Timor).

W. guadalupense guadalupense Girty (**237**—4, 5). **Delaware Mountain:** Tex.

TIMORITES Haniel 1915

(**T. curvicostatus*). Intermediate between typical *Waagenoceras* and typical *Cyclolobus*; differs from former in having more complicated sutures; differs from latter in having less advanced sutures. **U. Perm.** (Capitan of west Texas and Coahuila; Amarassi of Timor).

T. uddeni Miller and Furnish (**237**—2, 3). **Capitan** of Glass Mountains, Tex.

CYCLOLOBUS Waagen 1887

(**Phylloceras oldhami* Waagen). Conch smooth with relatively shallow umbilicus; whorls somewhat compressed, with broadly rounded external side, deeply embracing. **U. Perm.** (Greenland; Madagascar; India).

***C. oldhami** (Waagen) (**237**—11, 12). **U. Perm.:** India.

MEEKOCERAS Hyatt 1879

(**M. gracilitatis* White). Compressed, discoidal, involute or evolute, sides flattened; venter narrow, either flattened or rounded, no keels or furrows; umbilicus narrow or wide; living chamber short; surface smooth or with lateral folds; no tubercles, spines, or spiral ridges; septa ceratitic, with rounded entire saddles and serrated lobes; external lobe short and divided by siphonal saddle; the two lateral lobes longer, and there is an auxiliary series present in most forms, consisting of either a single lobe (serrated or goniatitic) or a series of denticulations, some of which may be partly individualized into lobes; internal septa consist of a divided antisiphonal lobe, flanked by a single lateral, although in some specimens there may be internal auxiliaries. **L. Trias.** (Idaho, Cal.; India; Siberia).

***M. gracilitatis** White (**237**—9, 10). **L. Trias.:** Idaho, Cal.

CLYPEOCERAS Smith 1913

(**Aspidites superbus* Waagen). Like *Meekoceras* (*Koninckites*), but differing in its greater involution and greater complexity of auxiliary series, both external and internal. **L. Trias.** (worldwide, occurring in Idaho and Cal.; Hungary; Albania; Timor; Salt Range and Himalayas of India).

PLATE 240

[Figures are x1 and after Reeside [USGS, PP 150, 151] unless otherwise indicated.]

1–11. Baculites spp. 1, 2. B. aquilaensis. Cross section and side view of the type. **3–5. B. compressus.** Side view, cross section, and suture. **6–8. B. ovatus.** A young shell with initial coils (x10); end and side views of a typical specimen. **9. B. gracilis** [USGS, B 106]. Side view and cross section. **10, 11. B. codyensis.** Cross section and side view. **12. Hamites (Idiohamites) fremonti** [USGS, An Rp 21 (7)]. **13, 14. Harpoceras propinquum** [R Soc Can, Tr 26]. Ventral and side views. **15, 16. Strebilites uhligi** [Inst Geol Mex, B 29]. Ventral and side views. **17, 18. Ochetoceras mexicanum** [Inst Geol Mex, B 29]. Side and ventral views.

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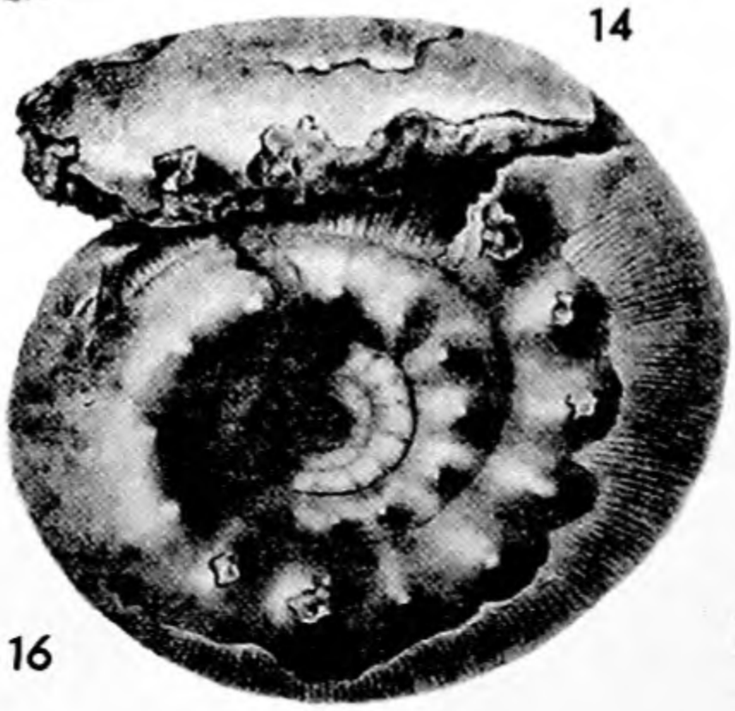

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C. pusillum Smith (**237**—6–8), **L. Trias.** (Meekoceras zone): Cal.

ANASIBRITES Mojsisovics 1896

(**Sibrites kingianus* Waagen). Moderately involute, somewhat compressed laterally; venter rounded or flat, in some specimens with shallow depression bordered by shoulder angles; transverse section rounded or subangular, usually higher than wide; sculpture consisting of numerous ribs, which in youthful shells are invariably coarse and every third or fourth one stands out as a distinct collar rib; ribs obsolete in maturity. **L. Trias.** (worldwide distribution; Idaho, Utah, Nev., Cal.).

***A. kingianus** (Waagen) (**238**—1–3). **Pinecrest:** Utah.

CUCCOCERAS Diener 1905

(**Trachyceras cuccense* Mojsisovics). Conch evolute, widely umbilicate; sides flattened, shoulders abrupt, venter narrow and low; septa ceratitic, lacking the auxiliary lobe; surface bearing ribs and constrictions that cross the venter without interruption. **M. Trias.** (western N. America; Mediterranean region; India).

C. bonae-vistae (Hyatt and Smith) (**238**—4–7). **M. Trias.:** Nev.

TIROLITES Mojsisovics 1878

(*"*Ceratites*" *idrianus* Hauer). Evolute *Ceratites*, robust, with square abdominal shoulders against which the simple ribs end in spines; *Metatirolites* (**U. Trias.**) has a distinct auxiliary lobe on the umbilical shoulder. **L. Trias.** (western N. America; Alps).

T. (Metatirolites) foliaceus Dittmar (**238**—8–10). Venter broadly rounded with growth lines arching sharply forward; ventral borders marked by strong tubercles. **U. Trias.:** Cal.; Alps.

CERATITES Haan 1825

(*"*Ammonites*" *nodosus* Bruguière). "Form genus"; moderately involute; whorls not deeply embracing, increasing rather rapidly in diameter, thus causing umbilicus to widen; subquadratic in section, usually higher than wide, with square abdominal shoulders and flattened venter; surface with ribs, which begin with nodes near umbilicus and end in nodes at ventral margin; suture with rounded, generally entire saddles, and serrated lobes, of which there are a divided external, two laterals, and several small auxiliaries. **Trias.** (western N. America).

C. humboldtensis Hyatt and Smith (**238**—11–14). Ribs curving, bifurcating; tubercles elongate; suture with slightly notched or wavy saddles and principal lobes serrated. **M. Trias.:** Nev., Cal.

C. (Gymnotoceras) russelli Smith (**238**—15–17). Whorls deeply embracing; venter with median keel; surface with strong, dichotomous ribs dividing one-third of listance from umbilicus and bending sharply forward; at point of bifurcation the ribs form low, radially elongate knots, and at the deep, umbilical, abruptly rounded shoulders are often developed weak tubercles; sutures with slightly notched saddles; typical of the *C. blakei* Gabb group. **M. Trias.:** Nev.

ACROCHORDICERAS Hyatt 1877

(**A. hyatti* Meek). Moderately involute, with whorls laterally compressed; umbilicus moderately wide and deep, with abrupt umbilical shoulders; surface bearing strong ribs bundled on umbilical knots, continuing across venter; sutures ceratitic. **M. Trias.**

***A. hyatti** Meek (**238**—18–20). **M. Trias.:** Nev.

TRACHYCERAS Laube 1869

(**T. chiesense* Mojsisovics). Genus comprises a series which begins with compressed and discoidal forms and ends with robust ones; they all occur together and do not represent an evolutionary series; species included are **T. leconteі** Hyatt and Smith, **T. shastense** Smith, **T. madisonense** Smith, all compressed; **T. lindgreni** Smith, intermediate; **T. beckeri** Smith, rugose and robust; and **T. californicum** Smith, very robust. **U. Trias.** (western N. America).

T. (Protrachyceras) shastense Smith (**238**—21–23). **Hosselkus** (Tropites zone): Cal.

COLUMBITES Hyatt and Smith 1905

(**C. parisianus*). Evolute, discoidal, with slightly embracing whorls, gradually increasing in size; body chamber long; surface bearing ribs, spirals, and frequent varices; suture ceratitic; retains its gastrioceran character until half grown, and at maturity it never gets beyond the ceratitic stage of the lobes. **L. Trias.** (western N. America).

***C. parisianus** H and S (**238**—24–26). **L. Trias.:** Idaho.

TROPITES Mojsisovics 1875

(**Ammonites subbullatus* Hauer). Moderately evolute, not deeply embracing, with deep, open umbilicus with steep walls; whorls usually broader than high, with angular, prominent, umbilical shoulders and arched venter; surface with strong umbilical nodes and spiral lines; septa ammonitic. **U. Trias.** (Cal.; Tyrolian Alps; India).

PLATE 241

[Figures are x1 unless otherwise indicated.]

1, 2. Haploceras zacatecanum [Inst Geol Mex, B 23]. **3–5. Mazapilites symonensis** [Inst Geol Mex, B 33]. **6, 7. Defonticeras defontii** [Nat Mus Can, B 54]. Two views of holotype. **8–10. Glochiceras fialar** [Inst Geol Mex, B 23]. Suture, and two views of a specimen. **11, 12. Fanninoceras fannini** [R Soc Can, Tr 26]. Two views of holotype. **13, 14. Kanastephanus crickmayi** [Nat Mus Can, B 54]. Two views of holotype. **15–17. Zemistephanus richardsoni.** 15, 16: Ventral view, restored, and lateral view of type specimen (x0.5) [CGS, Mes Fos], and ventral view of another specimen showing suture [Nat Mus Can, B 54].

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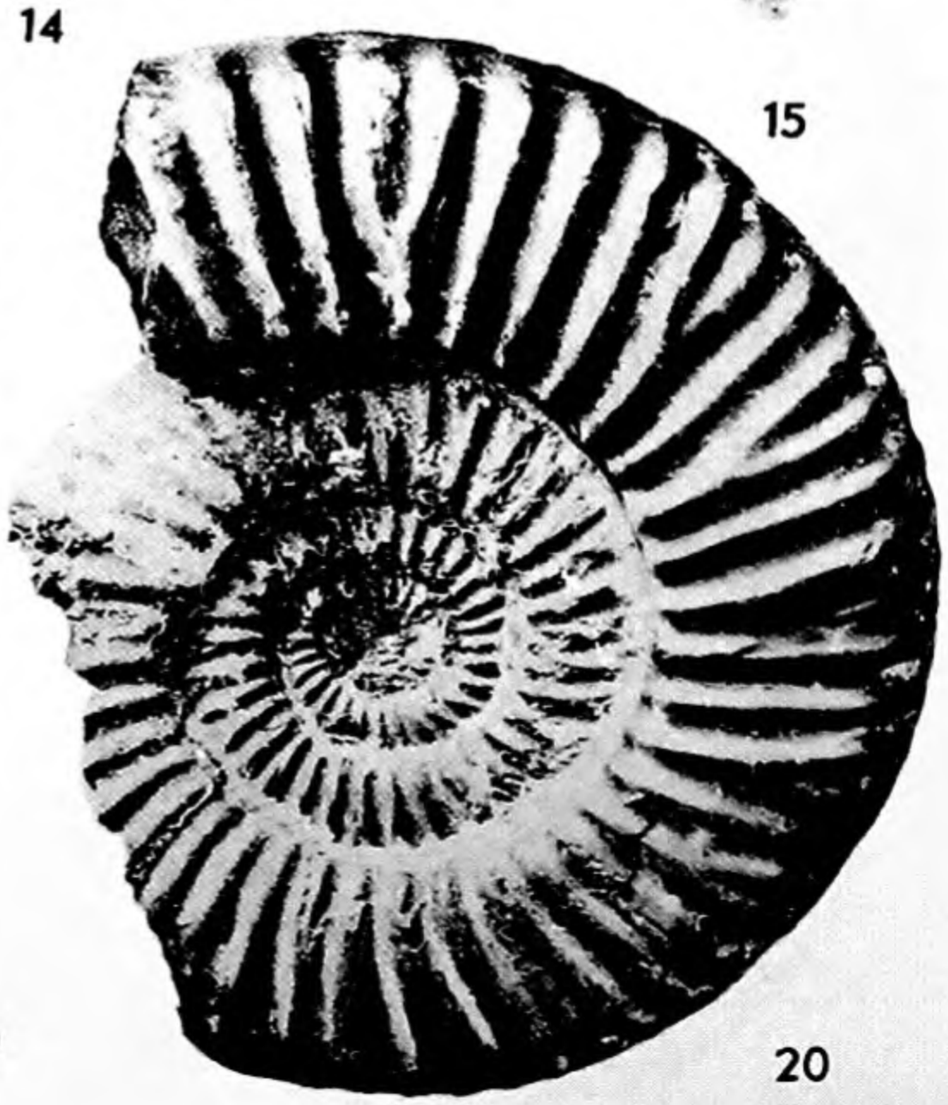

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***T. subbullatus** (Hauer) (**239**—1, 2). **U. Karnic:** Cal.

DISCOTROPITES Hyatt and Smith 1905

(**Ammonites sandlingensis* Hauer). Involute, discoidal, laterally compressed; venter narrow, acute, with high keel, which is sometimes hollow; surface with dichotomous, sickle-shaped ribs which become obsolete at base of keel; umbilical nodes and spirals (sometimes with nodes) are present; sutures ammonitic; living chamber long; young like adult *Tropites*. **Trias.** (western N. America).

***D. sandlingensis** (Hauer) (**239**—4–6). Ribs single or dichotomous; sides flat, outer whorl one-half shell diameter; keel high and hollow. **Trias.:** Cal. (Hosselkus); Alaska (Juvavites zone, Admiralty Island); Alps.

ARNIOTITES Hyatt 1889

(**A. vancouverensis*). Shell evolute, discoidal, widely umbilicate, laterally compressed; whorls slender, with subquadrate outline, little embracing and little indented by inner whorls; surface with strong, simple, straight radial ribs and high ventral keel with marginal furrows. **U. Trias.**

***A. vancouverensis** Hyatt (**239**—3). **U. Trias.** (Pseudomontis zone): Alaska (McCarthy); B. C.; Cal.

ARCESTES Suess 1865

(**A. galeati*). Conch globose, involute, and deeply embracing with closed umbilicus; body chamber longer than last volution, often contracted and differing in shape from other whorls; whorls helmet-shaped with rounded venter and smooth surface, except for periodic varices; sutures ammonitic with numerous similar lobes and saddles. **Trias.** (Nev., Cal.; Alaska).

A. (Proarcestes) shastaensis Smith (**239**—7, 8). Cal. (Hosselkus); Alaska (Juvavites zone).

PSEUDOSAGECERAS Diener 1895

(**Pseudosageceras* sp. indet.). Discoidal, involute; venter narrow, furrowed, and bounded by sharp ridges; surface with growth lines and fine spirals; suture complex, the lobe partly trifid; umbilicus closed. **Trias.** (western U. S. A.).

P. intermontanum Hyatt and Smith (**239**—12, 13). Venter very narrow, with small furrow, when perfect bearing a central keel; saddles entire, lobes mostly bifid with lateral notches but fifth deeply trifid. **L. Trias.:** Meekoceras beds of Idaho and Cal., Columbites bed of Idaho, and between these two in Utah.

JUVAVITES Mojsisovics 1879

(**Ammonites ehrlichi* Hauer). Involute, laterally compressed, with convex sides and rounded venter; umbilicus narrow; whorls deeply embracing and deeply indented by inner whorls; form generally subglobose; surface ornamented with dichotomous ribs; septa ammonitic. **U. Trias.** (Pacific Coast of N. America).

J. (Anatomites) brockensis Smith (**239**—9–11). **U. Trias.:** Cal. (Hosselkus); Alaska (Juvavites zone).

SAGENITES Mojsisovics 1879

(**Ammonites reticulatus* Hauer). Shells subglobose, somewhat compressed with rounded sides, arched venter, narrow umbilicus, and dichotomous ribs which cross venter and are cancellated by spiral lines which often produce a series of short spines (*Trachysagenites* Mojsisovics); sutures complex; differs from *Trachyceras* in lacking interruption of ornamentation of venter. **U. Trias.** (western U. S. A.)

S. (Trachysagenites) herbichi Mojsisovics (**239**—14–16). **Karnic:** Cal.; Alps.

PHYLLOCERAS Suess 1865

(**Ammonites heterophyllus* Sowerby). "Form genus"; involute ammonites with umbilicus small or absent, laterally compressed with rounded venter; surface smooth or with obliquely forward extending lines or folds, which extend without break across venter; varices or constrictions may occur; suture with numerous lobes and saddles, regularly increasing toward venter; saddles ending in rounded, leaflike pinnules. **Jura., Cret.** (Pacific Coast; northern Mexico).

"P." (Hypophylloceras) onoense Stanton (**239**—19). **L. Cret.:** Cal. (Horsetown).

LYTOCERAS Suess 1865, emend Spath 1924

(**Ammonites fimbriatus* Sowerby). Discoidal, widely umbilicate, slightly embracing; sections of whorls almost circular; surface bearing growth lines, fine distant ribs, and often with constrictions in internal fillings; suture complexly incised, consisting of siphonal and antisiphonal lobes and two lateral lobes; the antisiphonal narrow, with cruciform branches and ending in points; the siphonal lobe is shorter than first lateral and is divided by a narrow, pointed saddle. **Jura., Cret.**

L. batesi Trask (**239**—17, 18). **L. Cret.:** Cal. (Horsetown).

PLATE 242

[Figures are x1 unless otherwise indicated.]

1–5. Cardioceras spp. [USGS, PP 118]. **1, 2. C. cordiforme.** Side view of inner whorl, and suture, of type. **3–5. C. distans.** Suture (x2), and two views of type. **6, 7. Idoceras viverosi** [GSA, B 50]. **8, 9. Durangites astillerensis** [GSA, B 50]. **10–12. "Perisphinctes" (Dichotomosphinctes) elisabethaeformis** (x0.5) [Inst Geol Mex, B 29]. Suture, and two views of a specimen. **13. Seymourites loganianus** (x0.5) [CGS, Mes Fos]. **14, 15. Aulacosphinctes wilfridi** [Inst Geol Mex, B 33]. **16, 17. Substeueroceras kelluml** (x0.5) [GSA, B 50] **18–20. Nebrodites rota** [Inst Geol Mex, B 29].

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HAMITES Parkinson 1811

(**H. attenuatus* Fitt in Pictet). "Form genus"; ammonites with three to four straight parts connected by two to three curved parts that form arcs of 180°, the whole shell lying in one plane with whorls widely separated; ribs commonly simple, passing without interruption entirely around shell and usually not tuberculate; suture with two strongly incised lateral lobes. **L. Cret.**

H. (Idiohamites) fremonti Marcou (**240**—12). Costae rather coarse, with faint tuberculation on ventral margin, becoming obsolete toward dorsum. **Washita:** Okla., Tex.; Mex.

BACULITES Lamarck 1799

(**B. anceps*). Shell with minute, closely coiled initial stage but quickly becoming straight and assuming the form of a staff, which with increasing age increases slowly in diameter; transverse section subtriangular, oval, or subcircular, though usually compressed laterally; living chamber large, aperture with long, straight, rounded extension on siphonal side and lateral sinuses; surface smooth or with low rounded ribs parallel to aperture and as a rule distinct only on flanks, or with low rounded nodes on flanks; suture generally has six saddles and six lobes, bifid except for the antisiphonal. **U. Cret.** (characteristic throughout N. America).

B. aquilaensis Reeside (**240**—1, 2). Characterized by early appearance and distinctness of arcuate ribs, its compressed form in cross-section, and its medium size in even the largest individuals. **U. Cret.:** Mont. (Eagle), Wyo. (Steele, Telegraph Creek, Pierre), Colo. (Pierre), Utah (Mancos), N. Mex. (Mancos).

B. codyensis Reeside (**240**—10, 11). Differs from *B. aquilaensis* in its smaller size and stouter cross-section, though not as stout as var. *obesus* of that species; much like *B. asper* Morton (which has about the same distribution as *B. aquilaensis*), in form and size, but differing in its close-set arcuate nodes, which are quite unlike the distant rounded nodes of *B. asper*. **U. Cret.:** Mont. (U. Niobrara), Wyo. (Cody), Utah (M. Niobrara, Mancos).

B. compressus Say (**240**—3–5). Large, regularly and rather rapidly tapering; transverse section compressed, tapered toward siphonal side; suture deeply digitate, with two terminal branches of first lateral lobe supported on slender stem; shell unsculptured and smooth except in largest specimens. **U. Cret.:** Mont. (Eagle–Fox Hills). Many specimens formerly referred to this species should be included in **B. ovatus haresi** Reeside.

B. gracilis Shumard (**240**—9). Small, slender, scarcely tapering; broad ovate to subelliptical in section; surface smooth or with numerous rounded, distinct costae or undulations, strongest on siphonal side; saddles and lobes, six each, only slightly incised. **U. Cret.** (Coloradoan, chiefly Niobrara): Tex. (Eagle Ford), Colo., Utah.

B. ovatus Say (**240**—6–8). Large, gradually tapering, more broadly ovate than *B. compressus*; suture somewhat less finely incised. **U. Cret.:** Ripley of Atlantic and Gulf Coast regions; Montanan of Great Plains and Rocky Mountain region—S. Dak. (Pierre), Mont. (Virgelle, Telegraph Creek), Wyo. (Telegraph Creek, Cody, Steele), Colo., Utah, and N. Mex. (Mancos in all), Tex. (Taylor); Alta., B. C.

B. ovatus haresi Reeside, which differs from the typical form only in possessing a compressed shell, includes many forms once referred to *B. compressus*, and has been reported from the **U. Cret.** with essentially the same range as the preceding, and also Pierre of Kan. and Sask.

HARPOCERAS Waagen 1869

(**H. falcifer*). "Form genus," characterized by numerous groups; the forms here described are represented in the Jurassic of Western Canada; Septicarinate platycones with convex, sloping inner margin with well rounded border; falciform ribs curve with fairly strong peripheral projection; suture deeply incised, fairly complex. **Jura.**

"H." propinquum (Whiteaves) (**240**—13, 14). **L. Jura.:** Queen Charlotte Islands, B. C. (Maude).

OCHETOCERAS Haug 1885

(**Ammonites canaliculatus* Buch). Distinguished by a sharp angular keel which persists throughout all growth stages; conch involute; aperture laterally compressed; costae falciform, strong, with position of flexing marked by lateral canal; suture line finely incised. **U. Jura.:** (Cuba; Mex. (Durango, Mazapil); England; France; Germany; Switzerland; Portugal; Spain; northern Africa; Persia; Caucasus Mountains, Balkans).

O. mexicanum Burckhardt (**240**—17, 18). **U. Oxfordian:** Cuba; Mex.

STREBLITES Hyatt 1900

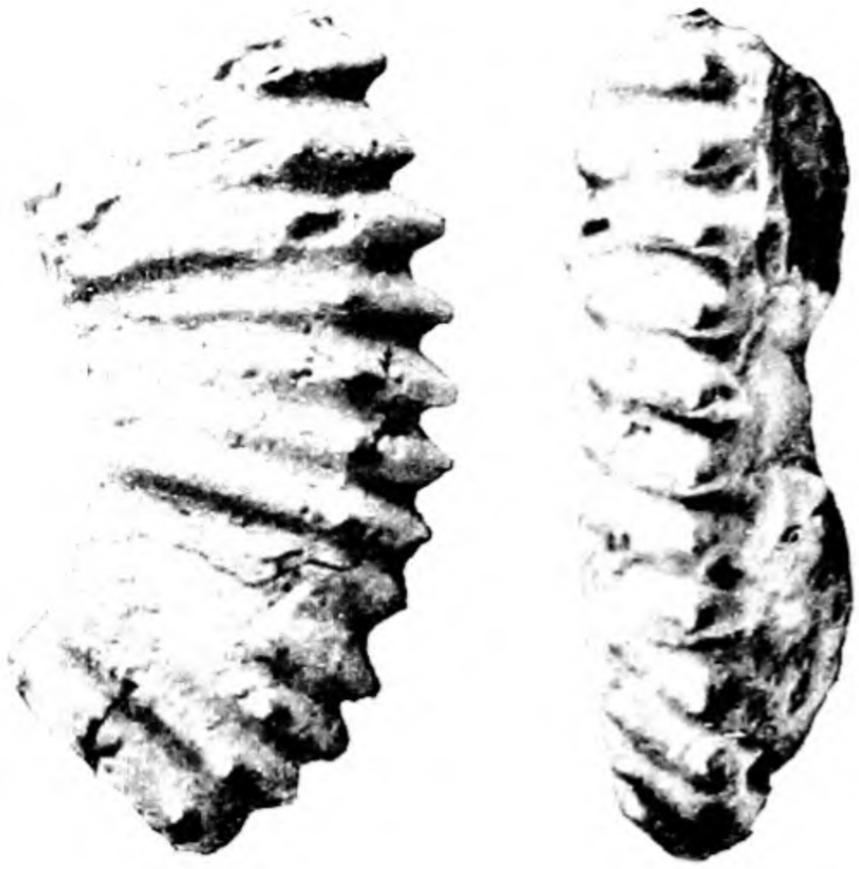
(**Ammonites tenuilobatus* Oppel = *Ammonites pictus costatus* Quenstedt). "Form genus," divided into several subdivisions or subgenera; the Mexican species described below belongs to the *S. uhligi* group as described by Burckhardt and comes from the **U. Jura.** (Kimmeridgian) of Durango (San Pedro del Gallo), Mex.

S. uhligi Burckhardt (**240**—15, 16). **Jura:** Durango.

PLATE 243

[Figures are x1 and after Imlay [GSA, B 49] unless otherwise indicated.]

1–3. Kossmatia victoria [Inst Geol Mex, B 23]. Two views, and suture. **4, 5. Neocomites kellumi.** Two views of holotype. **6, 7. Leopoldia victoriensis.** Two views of holotype. **8, 9. Acanthodiscus magnificus. 10–12. Discoscaphites nicolleti** [USGS, PP 150]. Two views of a specimen, and suture (x2). **13, 14. Distoloceras irregulare.** Lateral and ventral views of holotype. **15, 16. Dufrenoya justinae** [U Tex B 3945]. **17–19. Discoscaphites conradi** [USGS, PP 150]. Suture, and two views of a typical specimen.



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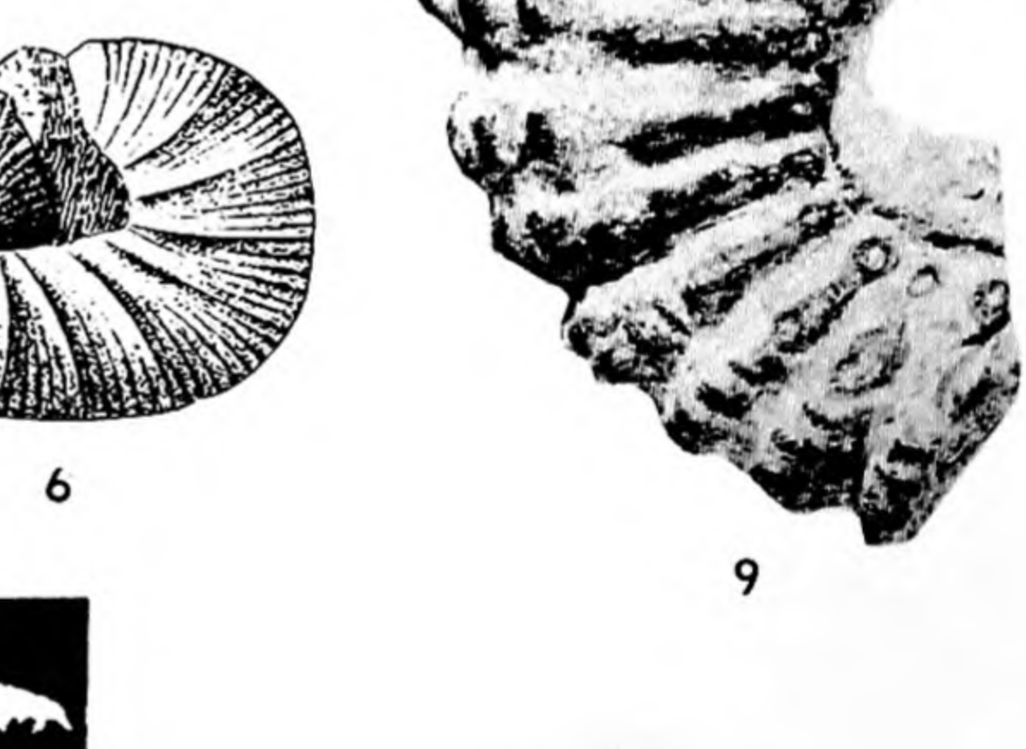

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FANNINOCERAS McLearn 1930

(**F. fannini*). Involute ammoniticones with overhanging undercut inner margin; ribbing typically costate, declining in some species, slightly flexuous on sides and variably bent forward on approaching the venter; suture moderately convex. **Jura.**

***F. fannini** McLearn (**241**—11, 12). **Jura.:** Western Canada.

MAZAPILITES Burckhardt 1919

(**M. symonensis*). Shell discoidal, almost involute; venter rounded, sides slightly convex; surface bearing numerous broad and rounded ribs which bifurcate ventrad; suture fairly complex. **Jura.** (Mexico–Mazapil, Zacatecas).

***M. symonensis** Burckhardt (**241**—3–5). **Jura.:** Zacatecas.

HAPLOCERAS Zittel 1887, emend Spath 1921

(**Ammonites elimatus* (Oppel) Zittel). Shell small, highly involute; whorls subovate; flanks flattened, subparallel; venter rounded; smooth or marked with falciform striae or folds. **U. Jura.** (Kimmeridgian to Tithonian) (worldwide distribution throughout a broad equatorial zone; Kimmeridgian only in Mex.).

H. zacatecanum Burckhardt (**241**—1, 2). **U. Jura.:** Zacatecas.

GLOCHICERAS Hyatt 1900

(**Ammonites nimbatus* Oppel). Shell small, very involute; whorls ovate; flanks ornamented with a spiral furrow, falciform striae, and falciform folds; venter rounded. **U. Jura.** (Kimmeridgian) (worldwide distribution).

G. fialar Burckhardt (*non* Oppel) (**241**—8–10). **U. Jura** (La Casita and La Caja): Many localities in north-central Mex.; Durango, Nuevo León.

DEFONTICERAS McLearn 1927

(**D. defontii*). Inner whorls and posterior part of last whorl asphericonic, with very small umbilicus, followed by marked and abrupt umbilical enlargement on anterior half of last whorl; living chamber about three-fourths of whorl; primary ribs fairly stout and slightly inclined, secondary ribs transverse in ventral area; no tubercles; suture complex. **Jura.** (western Canada).

***D. defontii** McLearn (**241**—6, 7). **Jura.:** B. C. (Yakoun).

KANASTEPHANUS McLearn 1927

(**K. crickmayi*). Whorls thicker than high; living chamber nearly three-fourths of a whorl; primary ribs increase to greatest number on last whorl, secondary ribs decrease in number on last whorl; there is a single row of lateral tubercles; suture fairly simple. **Jura.**

***K. crickmayi** McLearn (**241**—13, 14). **Jura.:** B. C. (Yakoun).

ZEMISTEPHANUS McLearn 1927

(**Ammonites richardsoni* Whiteaves). Primary ribs end in tubercles and are becoming less prominent on last whorl though persisting to aperture; suture moderately complex. **Jura.** (western Canada).

***Z. richardsoni** (Whiteaves) (**241**—15–17). **Jura.:** B. C. (Yakoun).

CARDIOCERAS Neumayr and Uhlig 1881

(**Ammonites cordatus* Sowerby). Involute ammonites with angular venter and triangular section; umbilicus moderate but deep; older whorls rounded, younger sharp-ventered and often pinched into a keel; adult invariably sharp-ventered; living chamber of adult smooth; umbilicus wide only in youth, umbilical shoulders of adult sharp, overhanging line of involution; ribs well marked on young of many species at stage where shell has diameter of 10 mm, usually sickle-shaped; older individuals have straighter ribs, commonly tuberculate; ribs usually bifurcate once, some twice, and usually show sharp, siphonal sinus. **Jura.** (S. Dak., Wyo., Utah; B. C.; Alaska).

C. cordiforme (Meek and Hayden) (**242**—1, 2). Characterized by evenly curved, unshouldered flanks of whorls; narrow umbilicus; fine, low, shallow, sigmoid ribs persisting in some individuals to a diameter of perhaps 200 mm; wide siphonal lobe and narrow superior saddle of suture. **Jura.:** S. Dak., Wyo. (Sundance).

C. distans (Whitfield) (**242**—3–5). Characterized by stout form, coarse sculpture, and moderately wide umbilicus. **Jura.:** Wyo. (Sundance); Alaska (Naknek).

IDOCERAS Burckhardt 1906

(**Ammonites planula* Zieten). Conch discoidal, generally flat, venter rounded; surface bearing prominent principal oblique costae which subdivide ventrad into two secondary branches; costae generally straight or but slightly curved, except on venter where they are crimped forward chevronlike; suture fairly simple. **Jura.** (Mex.; southern Europe; northern Africa).

I. viverosi Burckhardt (**242**—6, 7). **U. Jura.:** Nuevo León, Zacatecas.

PLATE 244

[Figures are x1 unless otherwise indicated.]

1, 2. Phlycticrioceras oregonense [USGS, PP 150]. Two views of the type (also see **249**—11, 12). **3. Oxytropidoceras beiknapi** (x0.2) [U Tex B 2838]. **4–6. Scaphites** spp. **4, 5. S. hippocrepis** [USGS, PP 151]. **6. S. warreni** [USGS, B 106]. **7, 8. Gastropilites canadensis** [R Soc Can, Tr 27]. Ventral and lateral views of holotype. **9. Douvilleiceras mammillatum** [U Tex B 3945]. Lateral view of a partial volution. **10. Scaphites ventricosus,** with apertural portion restored [USGS, PP 150]. **11, 12. Spiticeras uhligi** [Inst Geol Mex, B 29]. Suture, and lateral view of a fragmental specimen.

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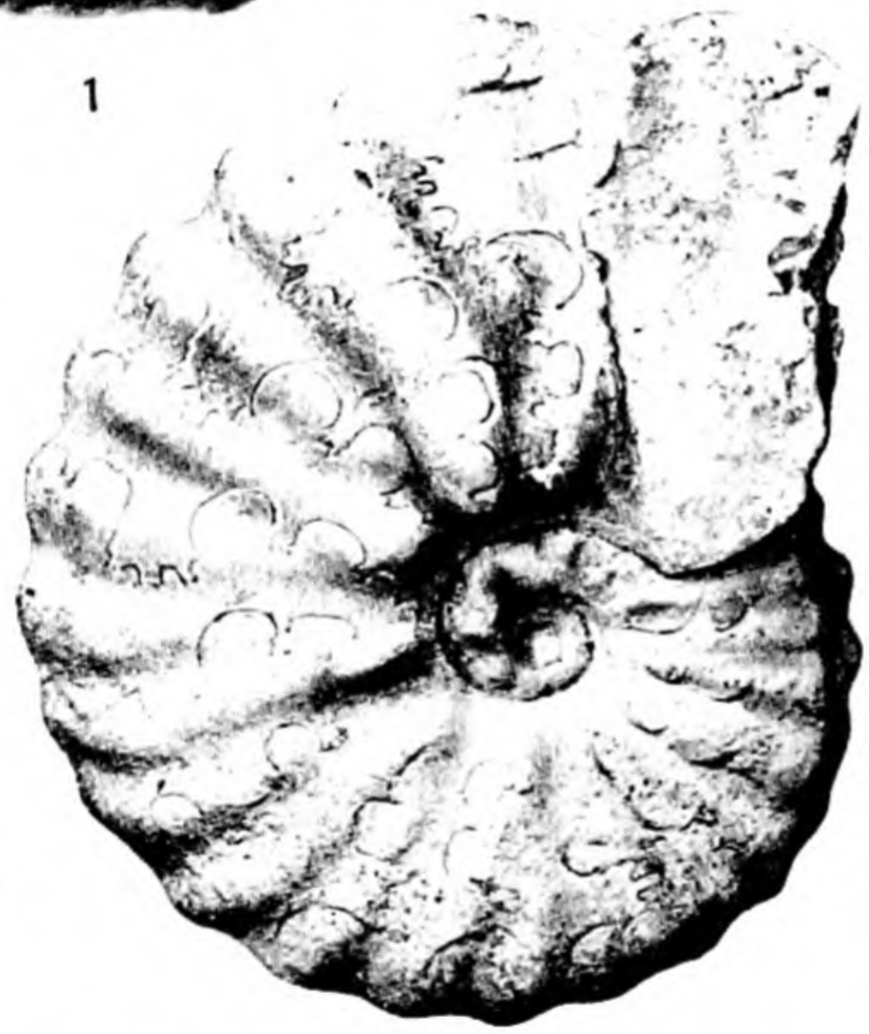

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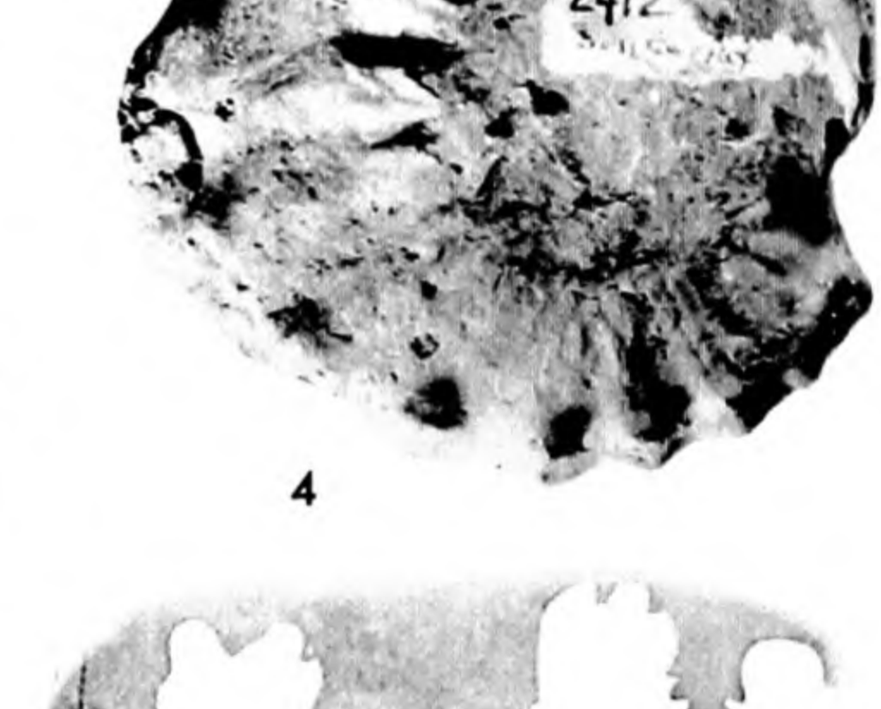

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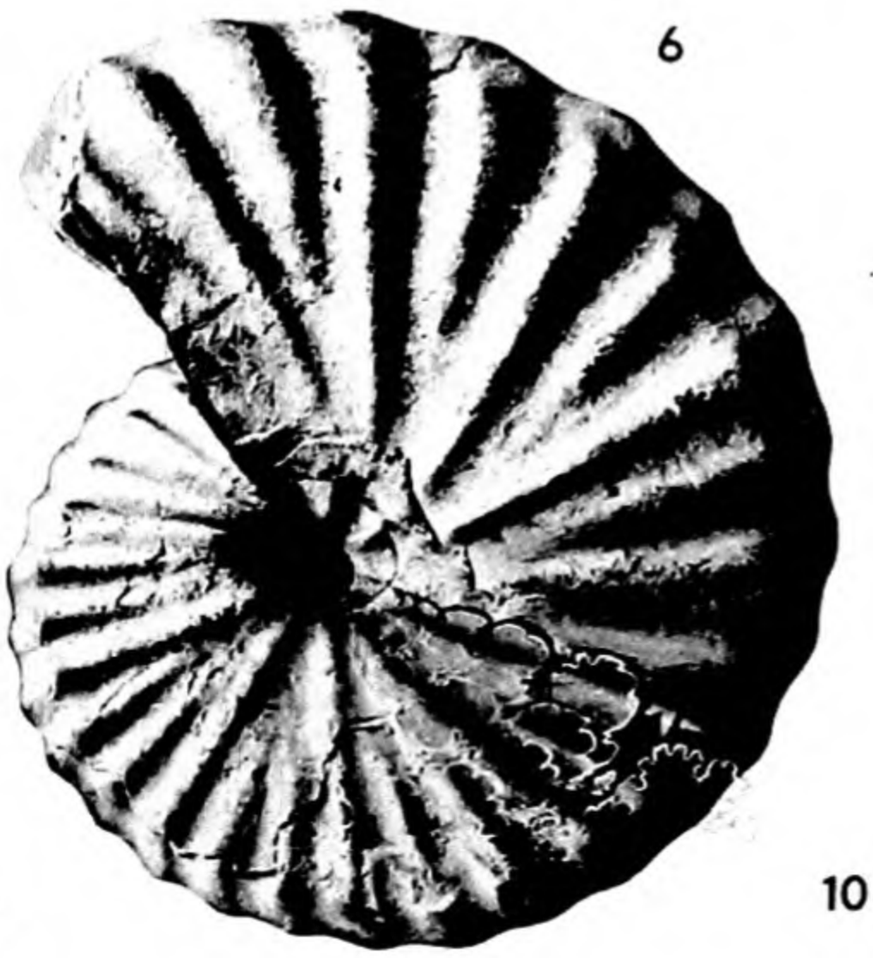

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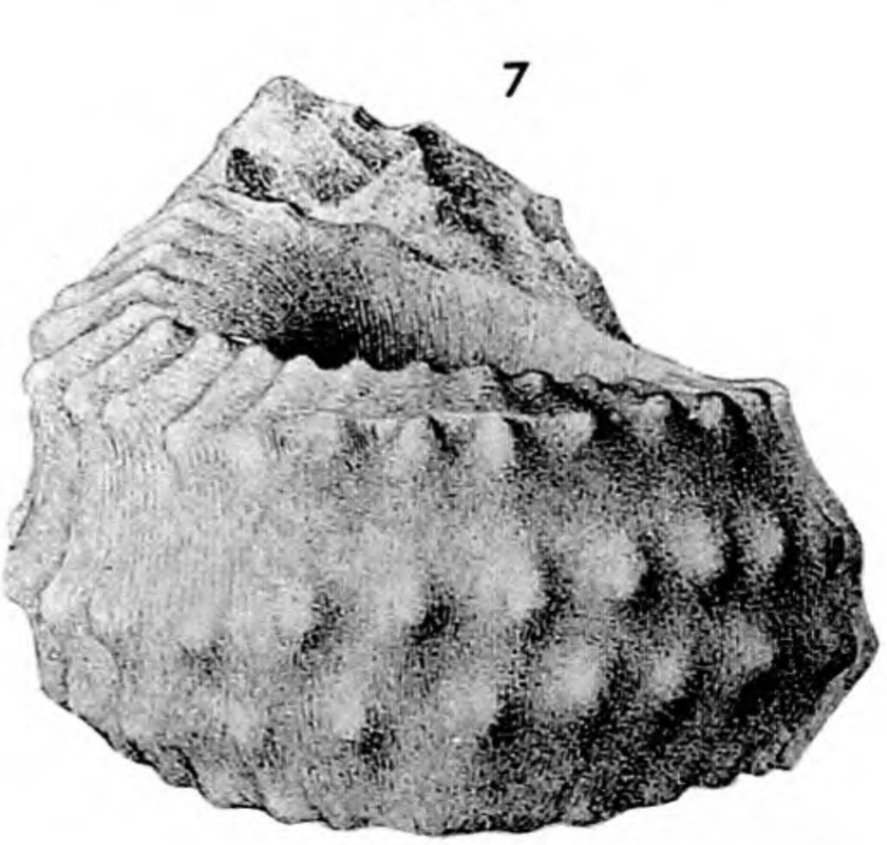

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SEYMOURITES Kilian and Reboul 1909

(**Ammonites loganianus* Whiteaves). Ribs numerous, narrow, and elevated; a single row of small, lateral tubercles; suture florid. **Jura.** (western Canada).

***S. loganianus** (Whiteaves) (**242**—13). Anterior part of penultimate whorl has small umbilicus; marked umbilical enlargement on anterior part of last whorl; whorls fairly stout, broad and rounded on venter; primary ribs angular, straight, and inclined on sides, outside inner margin, and end in tubercles; narrow, elevated secondary ribs branch from each tubercle. **Jura.:** B. C. (Yakoun).

PERISPHINCTES Waagen 1869

"Form genus," which has been subdivided into so many genera and subgenera that it no longer has precise stratigraphic significance. There follow several perisphinctid species which show typical characters of the group.

"P." (Dichotomosphinctes [Buckman 1926: ***Perisphinctes wartae antecedens** Salfeld]) **elizabethaeformis** Burckhardt (**242**—10–12). **U. Jura.:** Cerro del Volcán, Mex.

AULACOSPHINCTES Uhlig 1910

(**Ammonites môrikeanus* Oppel). Perisphinctids with ventral groove; umbilicus large; whorls slightly overlapping; costae forked or simple. **Jura.**

A. wilfridi (Burckhardt) (**242**—14, 15). **Jura.:** Mex.

NEBRODITES Burckhardt 1912

(**Simoceras agrigentium* Gemmellaro). Conch evolute; suture fairly complex; surface strongly costate. **U. Jura.** (Mex.; central Europe; northern Africa).

M. rota Burckhardt (**242**—18–20). **U. Jura.:** Durango.

DURANGITES Burckhardt 1912

(**D. acanthicus*). Conch rather small, flattened, with more or less open umbilicus; venter more or less flattened, umbilical wall abrupt, and transverse section of whorls rounded, square or rectangular; whorls generally increase slowly; ornamentation changes considerably with age, and consists of prominent costae and tubercles. **U. Jura.** (U. Portlandian of Mex).

D. astillerensis Imlay (**242**—8, 9). **La Casita** (Durangites beds): Coahuila.

SUBSTEUEROCERAS Spath 1923

(**Odontoceras koeneni* Steuer). Shell moderately involute; flanks gently rounded; venter flattened, often broad; ribs flexuous, simple to bidichotomous, continuous across venter in adult. **U. Jura., ?L. Cret.** (only in Tithonian in Mex.).

S. kellumi Imlay (**242**—16, 17). **U. Jura.** (La Casita): Coahuila.

KOSSMATIA Uhlig 1910

(**Ammonites tenuistriatus* Gray). Ammoniticone, generally involute; surface bearing strong primary ribs which split ventrad into two or three branches; sutures phylliform. **U. Jura., L. Cret.** (Portlandian to Berriasian) (widespread in equatorial belt from Mex. to India; found only in Portlandian in Mex.).

K. victoris (Burckhardt) (**243**—1–3). **Jura.:** Mazapil.

NEOCOMITES Uhlig 1905, emend Spath 1921

(**Ammonites neocomiensis* Orbigny). Shell fairly involute, compressed; venter truncated; flanks flattened; whorls increasing rapidly in size, ribs fine, flexuous, frequently bidichotomous, terminating in small ventral tubercles; strong development of first saddle and first lateral lobe. **Jura., L. Cret.** (worldwide distribution, with maximum development in Valanginian).

N. kellumi Imlay (**243**—4, 5). **L. Cret.** (L. Hauterivian): Northern Mex. (Taraises).

DISTOLOCERAS Hyatt 1900

(**Ammonites hystrix* (Bean) Phillips). Shell discoidal, flattened, slightly involute, widely umbilicated; trituberculate ribs alternate with nontuberculate ribs in adult; in early stages bundles of falciform ribs arise from umbilical tubercles and terminate in ventral tubercles; whorls increasing moderately in size; venter rounded, usually smooth; sutures similar to those of *Neocomites*. **Cret.** (Valanginian and Hauterivian; worldwide distribution throughout a broad equatorial zone).

D. irregulare Imlay (**243**—13, 14). **L. Cret.** (L. Hauterivian): Coahuila (Taraises).

ACANTHODISCUS Uhlig 1905, emend Spath 1921

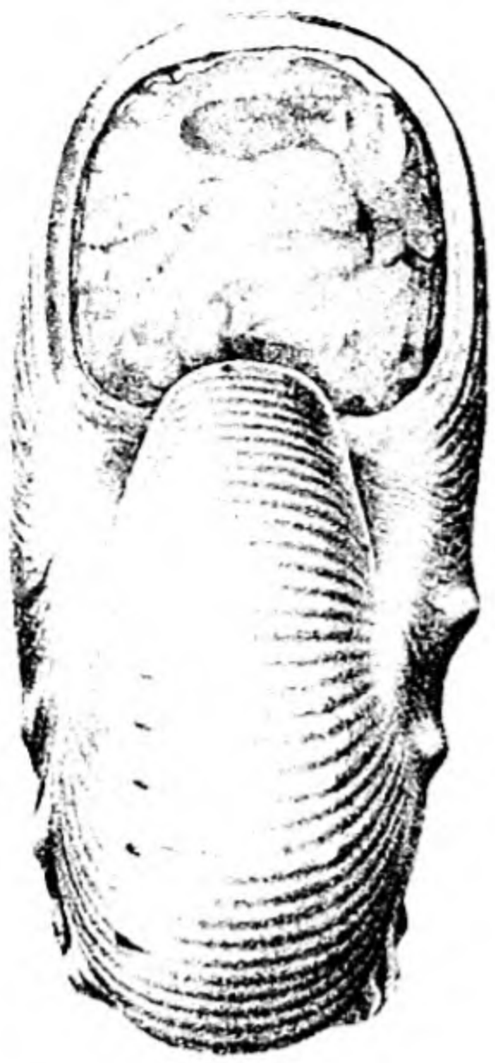
(**Ammonites radiatus* Bruguière). Shell large, fairly involute (one-half to one-third); narrowly umbilicated; trituberculate in adult; passes through an early costate stage; whorls increasing rapidly in height and thickness; midventral region smooth; lobes and saddles wide at their base; first lateral lobe unsymmetrical, with main branch higher and narrower than in *Leopoldia*. **Cret.** (worldwide distribution throughout a broad equatorial zone).

A. magnificus Imlay (**243**—8, 9). **L. Cret.** (Valan-

PLATE 245

[Figures are x1 unless otherwise indicated.]

1, 2. Beudanticeras breweri [GSA, SP 16]. Side and front views of holotype, slightly less than x1. **3, 4. Acanthoceras stephensoni** (x0.5) [U Tex B 2338]. Two views of holotype. **5, 11. Turrilites brazoensis** [USGS, An Rp 21]. Two fragmental specimens. **6–10. Metoicoceras** spp. (x0.5) [USGS, M 44]. **6, 7. M. swallovi.** Lateral view, and portion of suture (x12). **8–10. M. whitei.** 8: Suture from specimen of about same size as that shown in 9 and 10; two views of a well preserved specimen.



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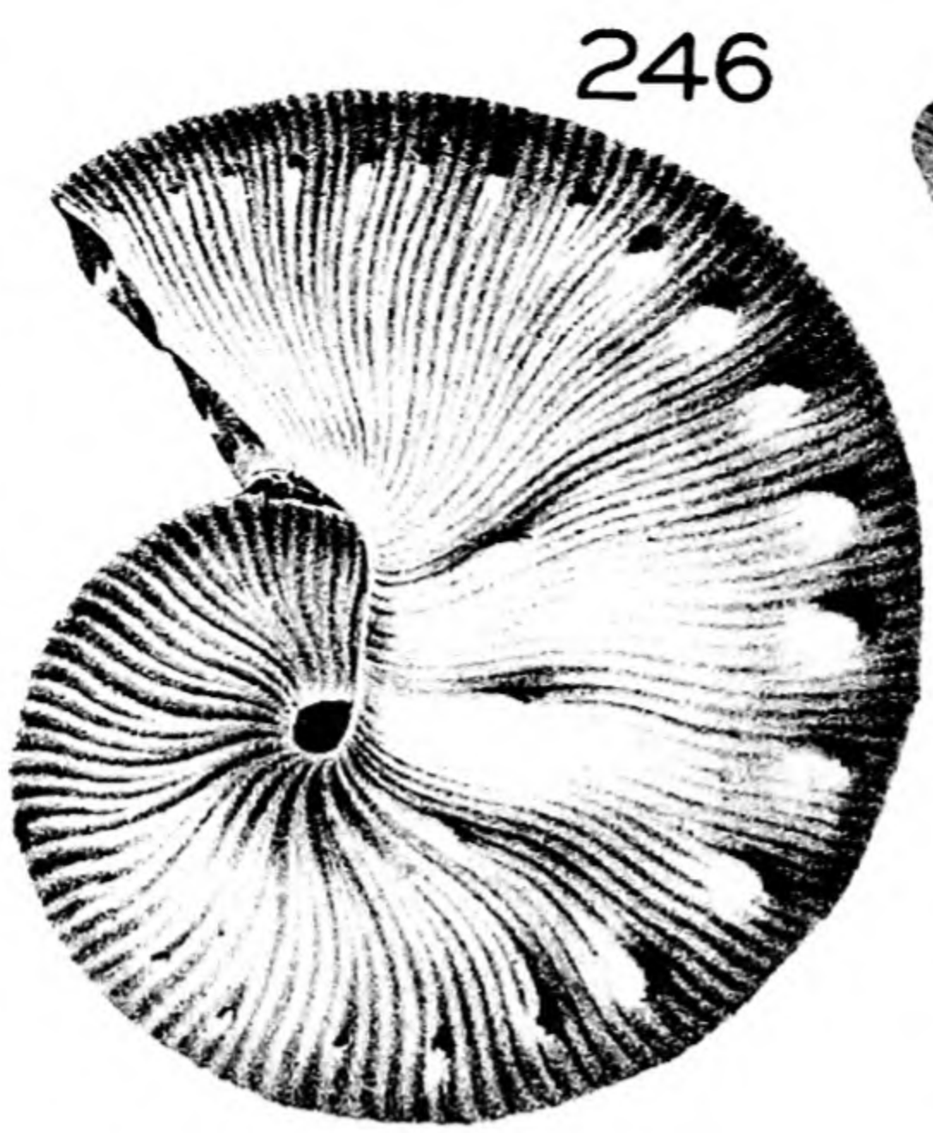

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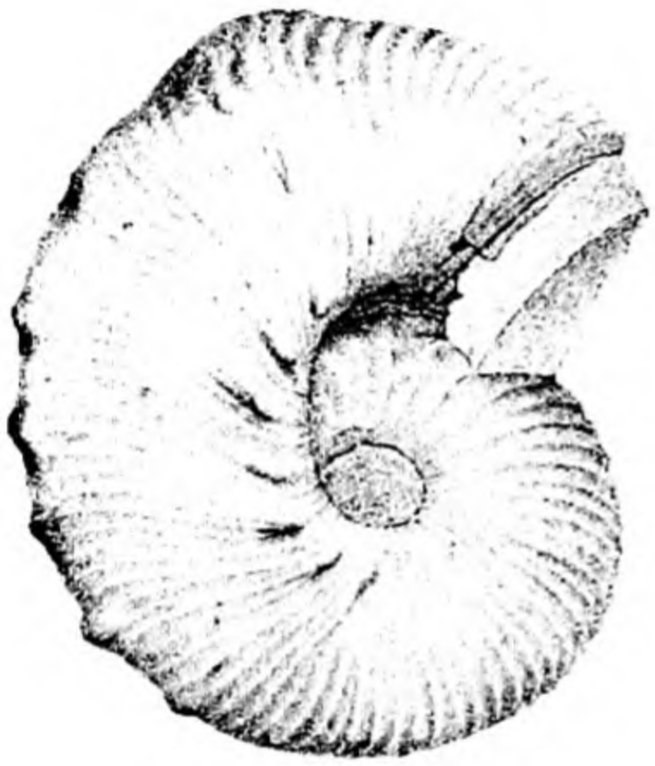

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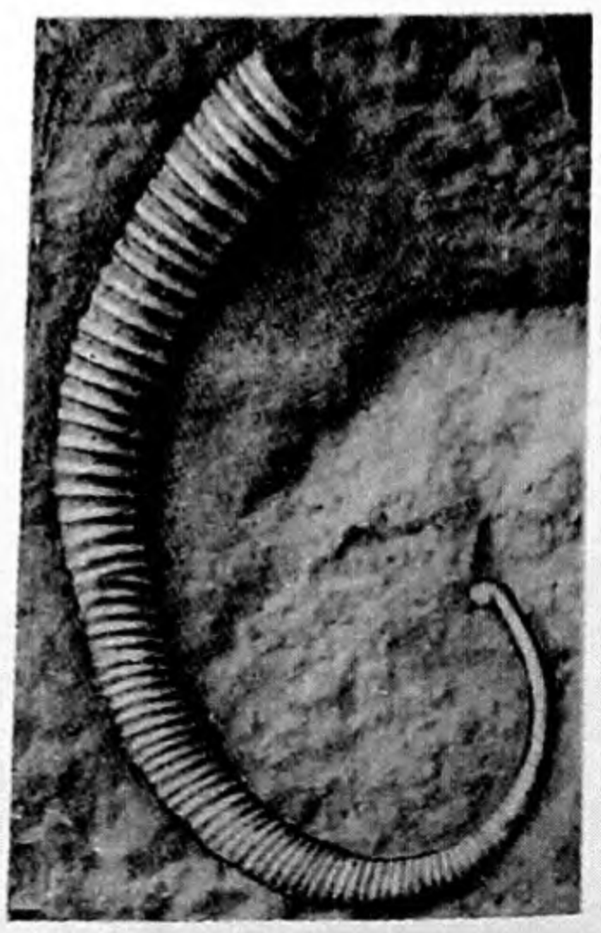

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ginian and Hauterivian, particularly latter): Coahuila (Taraises).

LEOPOLDIA Mayer 1887

(**Ammonites leopoldinus* Orbigny). Shell large, discoidal, much compressed, strongly involute, narrowly umbilicated; venter flat to rounded and smooth; early stages with flexuous, simple ribs which terminate in umbilical and ventral tubercles; in later stages ribbing becomes reduced on middle part of flanks, and large adult whorls become completely smooth. **L. Cret.** (Valanginian to Hauterivian) (equatorial belt from Mex. to the Caucasus at least).

L. victoriensis Imlay (**243**—6, 7). **L. Cret.** (L. Hauterivian): Mex. (Taraises).

DUFRENOYA Kilian 1915
(= STENHOPLITES Spath 1922)

(**Ammonites dufrenoyi* Orbigny). Conch discoidal, compressed, involute or somewhat evolute; venter truncate, forming marked angle with sides; surface bearing flexuous costae. **L. Cret.** (Aptian) (Tex.; Mex.; Columbia; Africa).

D. justinae (Hill) (**243**—15, 16). **Aptian:** Tex. (Trinity); Mex.

DISCOSCAPHITES Meek 1876
(= HOPLOSCAPHITES Nowak 1911)

(**Ammonites conradi* Morton). Shells compressed with involute whorls, mostly of moderate size for the group; ribs curved, increasing in number by intercalation and bifurcation; nodes few or numerous on flanks; suture usually with first lateral lobe longest, external lobe next in length, and second lateral and auxiliaries much shorter; first internal saddle narrow, second wide; suture moderately incised; bifid lobes in adult arise from trifid embryonic lobes. **U. Cret.**

***D. conradi** (Morton) (**243**—17–19). **U. Cret.:** Md. (Monmouth), Ala. (Ripley), Great Plains and Rocky Mountain regions.

D. nicolleti (Morton) Meek (**243**—10–12). Like preceding but lacking double row of nodes on venter. **U. Cret.:** Western Interior.

GASTROPLITES McLearn 1930

(**Hoplites canadensis* Whiteaves). Conch involute, compressed, with well defined ventral shoulders and tabulate or only slightly arched venters; coarsely ribbed; suture reduced and simple. **L. Cret.** (Canadian Western Interior).

***G. canadensis** (Whiteaves) (**244**—7, 8). **Peace River:** Canada.

PHLYCTICRIOCERAS Spath 1926

(**Ancyloceras? douvillei* Grossouvre). Shell elongate, tubular, apparently lying in a single plane with whorls widely separated; coiling irregular, parts of shell nearly straight, parts much curved; ribs simple, bearing on siphonal line a high, sharp tubercle and on each ventrolateral shoulder a lower, rounded tubercle; constrictions at intervals bordered by ribs larger than other ribs; suture with two lateral lobes, deeply bifid, and three lateral saddles, also bifid, on each side between siphonal and antisiphonal lobes. **U. Cret.** (Western Interior).

P. oregonense Reeside (**244**—1, 2; **249**—11, 12). **Cody** of Mont. and Wyo.; **Mancos** of Utah.

OXYTROPIDOCERAS Stieler 1920

(**Ammonites roissyanus* Orbigny). Compressed ammoniticones, coiling polygyral; ribs numerous, flexuous, elevated; carina tall; first lateral saddle broad and distinctly asymmetrical. **Cret.** (U. Fredericksburg of Texas; M. and U. Albian of western Europe; Africa; S. America).

O. belknapi (Marcou) (**244**—3). Some ribs of last volution branched. **L. Cret.** (Kiamichi): Okla., Tex.

SPITICERAS Uhlig 1903

(**Ammonites spitiensis* Blanford). Shell discoidal, moderately involute; early whorls strongly depressed; later increasing more markedly in height than in thickness and forming a rounded or sharp venter; in adults ribs arise from umbilical tubercles in bundles of two to four, subdivide at various heights and form a marked angle on the venter; earlier whorls are doubly tubercular; two to three constrictions on each whorl. **U. Jura.–Cret.** (Tithonian to L. Valanginian; worldwide distribution throughout a broad equatorial zone).

S. uhligi Burckhardt (**244**—11, 12). **U. Jura.** (Berriasian): Durango (La Casita).

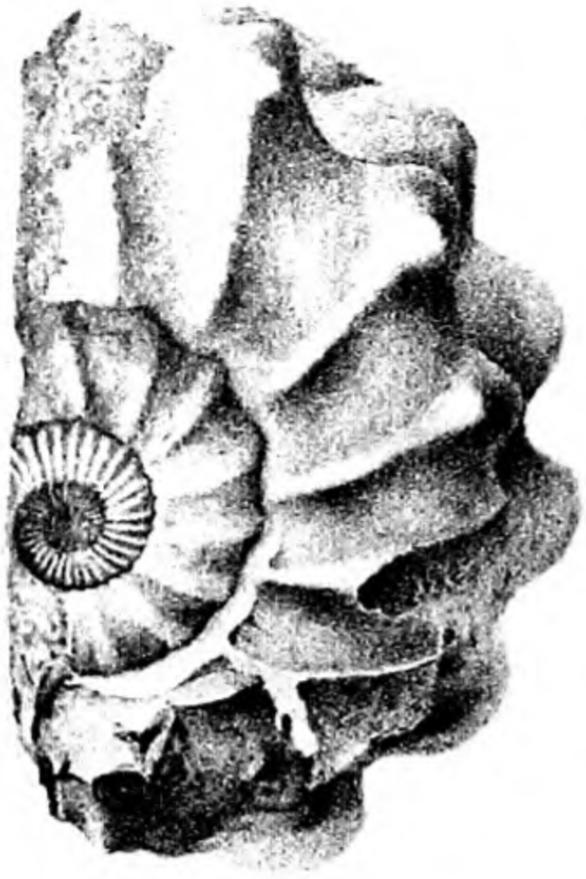
SCAPHITES Parkinson 1811, emend Reeside 1927
(= ANASCAPHITES Hyatt 1900, JAHNNITES Hyatt 1900, YEZOITES Yabe 1910, HOLCOSCAPHITES Nowak 1911)

(**S. aequalis* Sowerby). Umbilicus narrow, broader in youth, narrower in adult; whorls stout, last living chamber abnormal; ribs pass without nodes from umbilicus, end at edge of venter with nodose thickening, and then split into weaker secondary ribs; later the ribs of venter and flank are equal; lobes and saddles in external part of suture gradually smaller from outside of whorl inward; the same in internal part but in opposite direction; bifid lobes develop

PLATE 246

[Figures are x1 unless otherwise indicated.]

1–6. Acanthoscaphites spp. [1, 2, 4–6: USGS Ter 9. 3: Owen 1852, G Rp Wis, Ia and Minn]. **1, 2. A. nodosus brevis.** Two views of type of variety. **3. A. nodosus. 4–6. A. nodosus quadrangularis.** Two views of a specimen, and suture (x3). **7–9. Exiteloceras pariense** [USGS, B 106]. 7: Septum (enlarged) of 8, the type. 9: a small coiled specimen. **10, 11. Hellcoceras** spp. **10. H. navarroense** [USGS, PP 137]. **11. H. rubeyi** [USGS, PP 151]. Side view of type (x3). **12, 13. Emperoceras beecheri** [Am Phil Soc, Pr 32]. Top and side views.



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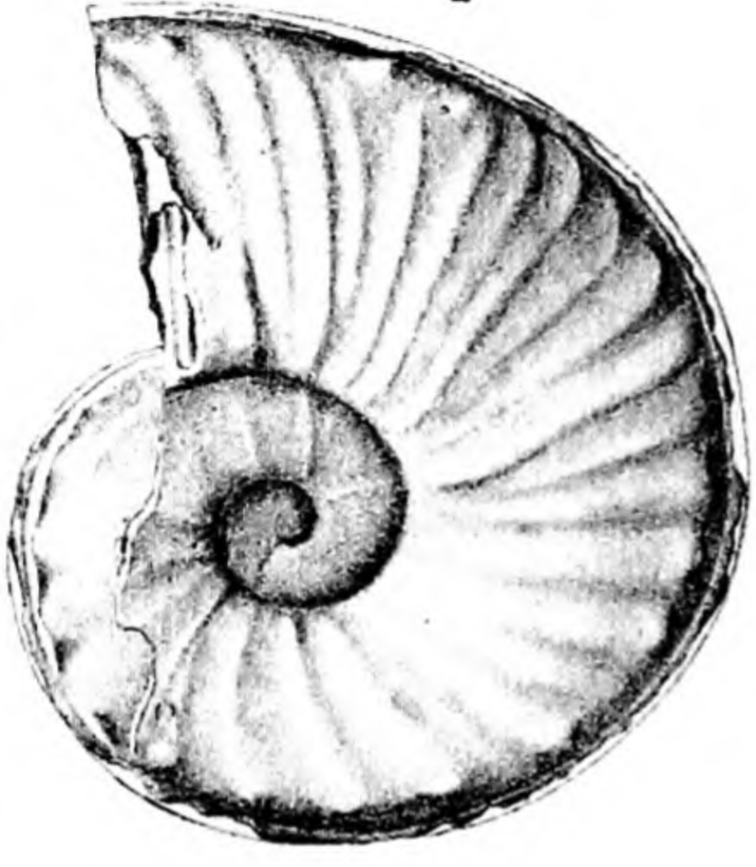

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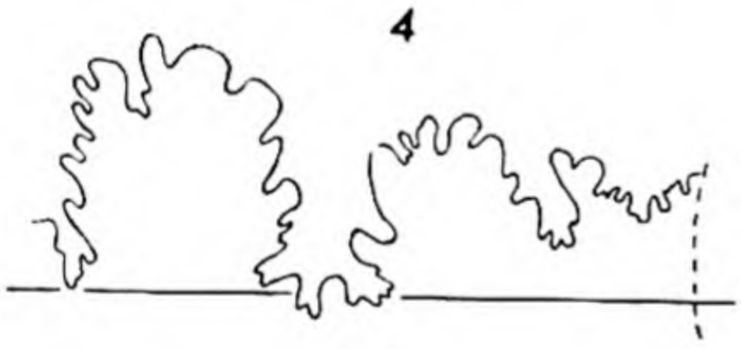

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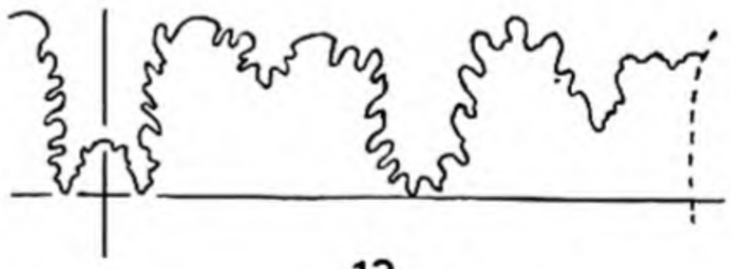

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out of trifid; internal lobe trifid. **U. Cret.** (widespread in **Cret.** provinces of U. S. A. and Canada; Europe).

S. warreni Meek and Hayden (**244**—6). Small; last whorl partly free; recurved ribs simple, alternating coarse and fine; adult suture very simple. **Benton:** Great Plains and Rocky Mountain regions.

S. hippocrepis (DeKay) (**244**—4, 5). Larger whorl ventricose, with eight prominent lateral tubercles, and two others more elevated at the inner margin on each side; back delicately ribbed between lateral tubercles; an obscure ridge from each of lateral tubercles to umbilical margin; no visible septa; smaller whorl compressed, half concealed, costate all around; septa numerous, serrated like those of an ammonite. **U. Cret.:** N. J. (Merchantville), Del. (Crosswicks), S. Dak. (Pierre), Mont. (Eagle, Telegraph Creek), Ark. (Marlbrook), Wyo. (Eagle, Telegraph Creek, Cody, Steele), Colo. (Mancos), Tex. (Austin, Taylor), N. Mex., Utah.

S. ventricosus Meek and Hayden (**244**—10). Shell characterized by stout, evenly rounded whorls, relatively fine ribs throughout, and lack of nodes. Widespread in the **Cret.,** and a guide fossil for the **Niobrara** (Coloradoan).

BEUDANTICERAS Hitzel 1905

(**Ammonites beudanti* Brongniart). Involute, discoidal shells; surface smooth or with periodic constrictions or ridges, occasionally costate; suture complex. **L. Cret.** (western N. America).

B. breweri Gabb (**245**—1, 2). **Shastan:** Mackenzie Valley, Canada; Cal.

DOUVILLEICERAS Grossouvre 1893, emend Spath 1923

(**Ammonites mammillatum* Schlotheim). Shells characterized by long and broad first lateral saddle, and by the peculiar form of the first lateral lobe of its suture; shape and sculpture diagnostic; shell evolute and inflated; whorls rounded or depressed with prominent, multituberculate costae. **Cret.** (Albian) of world.

***D. mammillatum** (Schlotheim), emend Spath (**244**—9). **M. Albian** of World: Tex. (Trinity), Cal. (Horsetown).

ACANTHOCERAS Neumayr 1875

(**Ammonites rhotomagensis* Defrance). Young shell discoidal, nontuberculate and section rounded till late youth; adult with straight, simple or bifurcating ribs, thickening outward with lateral and marginal tubercles; venter with median row of tubercles; suture deeply incised, first lateral saddle broad and bifid, ventral lobe straight and deep, with truncated siphonal saddle. **L. Cret.** (Alta; Kan., Colo., Tex.; Coahuila; France; England; Switzerland; India).

A. stephensoni Adkins (**245**—3, 4). **Eagle Ford:** Tex.

METOICOCERAS Hyatt 1903

(**Ammonites swallovi* (Shumard) Hyatt). Ammonites with compressed shells; umbilicus small, with or without umbilical nodes; ribs near umbilicus faint if nodes are lacking, strong and rounded if nodes are present; ribs somewhat flexed to nearly straight, usually forking on flank, intercalated secondary ribs common; shell surface nodose; living chamber usually scaphitoid in large individuals; suture simple, ceratitic. **Cret.** (western N. America).

***M. swallovi** (Shumard) (**245**—6, 7). **Coloradoan:** Tex., Utah.

M. whitei Hyatt (**245**—8-10). **Coloradoan:** Great Plains (Greenhorn of S. Dak., Mowry and Mosby of Wyo., Coloradoan of Utah and N. Mex.); Tex. (Eagle Ford); Coahuila.

ACANTHOSCAPHITES Nowak 1911

(**Scaphites tridens* Kner). Shells large with whorls somewhat higher than wide; ribs straight, with nodose thickening near umbilicus, intercalated secondary ribs, and in adults lateral and ventral nodes; suture with long external lobe, long bifid first lateral lobe, and much shorter second and auxiliary lobes; three internal saddles, decreasing regularly from dorsal lobe to line of involution; bifid lobes in adult suture developed from trifid embryonic lobes; suture much incised. **U. Cret.** (see species for distribution).

A. nodosus (Owen, *non* Lopuski) (**246**—3). Large with sides flattened; ribs bifurcating and increasing by intercalation, rounded, closely spaced; a strong node on every third to fifth rib near ventral border of last whorl; these become strong and spread over several ribs in first part of loose-coiling whorl but become smaller again toward aperture; a second row of nodes more distant occurs near the small umbilicus; typically the nodes of both rows continue over entire last whorl; in **A. nodosus brevis,** (**246**—1, 2) the tubercles of the outer row increase and diminish rapidly and do not cover the entire whorl, while the inner row has few nodes; in var. **quadrangularis** (**246**—4–6) the shell is small, nearly subquadrangular in section of whorl, with flattened venter, with nodes weak and of slight extent in each row. **Montanan:** Ripleyan of N. J., Great Plains and Rocky Mountain regions, Pierre of Kan.

PLATE 247

[Figures are x1 unless otherwise indicated.]

1, 2. Prionotropis woolgari [USGS Ter 9]. Two views of a fragmental specimen. **3–5. Prionocyclus wyomingensis** [USGS Ter Wyo and Idaho]. Two views of a half grown specimen, and suture. **6–16. Mortoniceras** spp. **6–8. M. texanum** [Roemer: Kreidebild Tex]. Suture enlarged, and two views of a partly grown specimen. **9–12. M. shoshonense.** Suture (x2) at 50 mm, and side, rear, and front views of a slightly squeezed specimen. **13–16. M. shoshonense.** Suture (x2) at 38 mm, and side, rear, and front views of a smaller specimen [9–16: USGS, PP 150].

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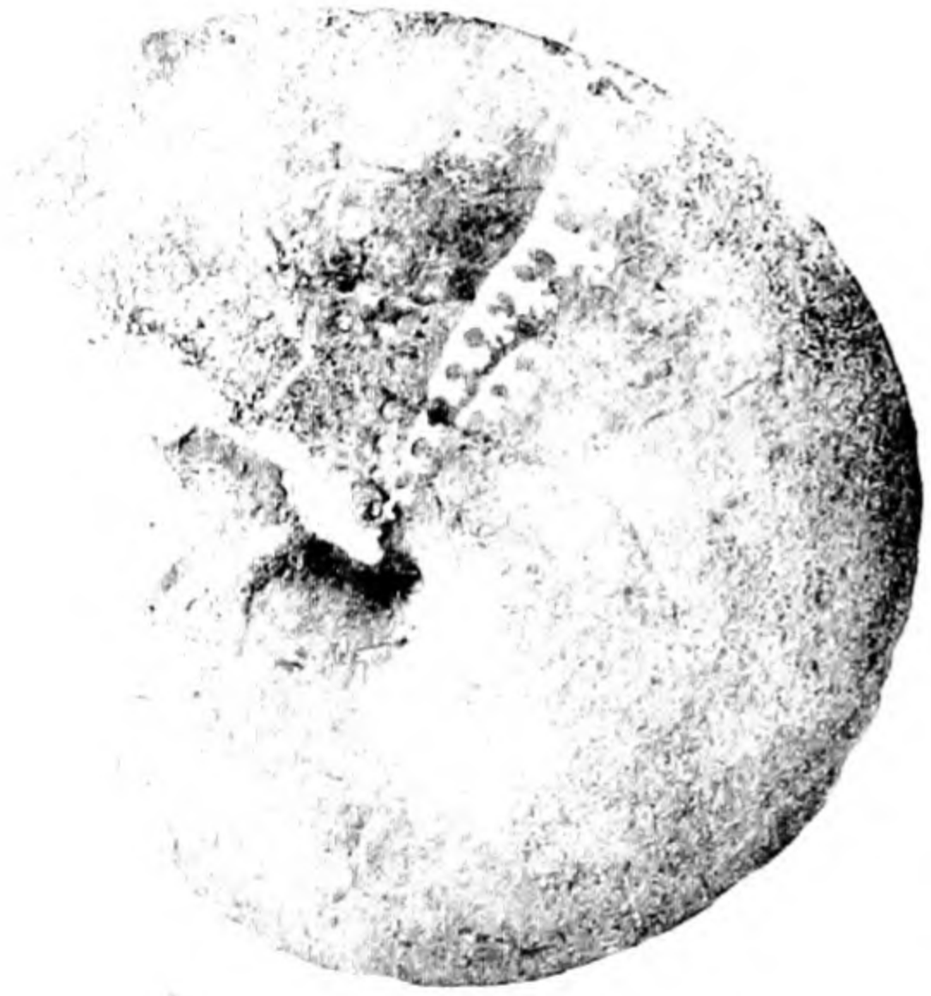

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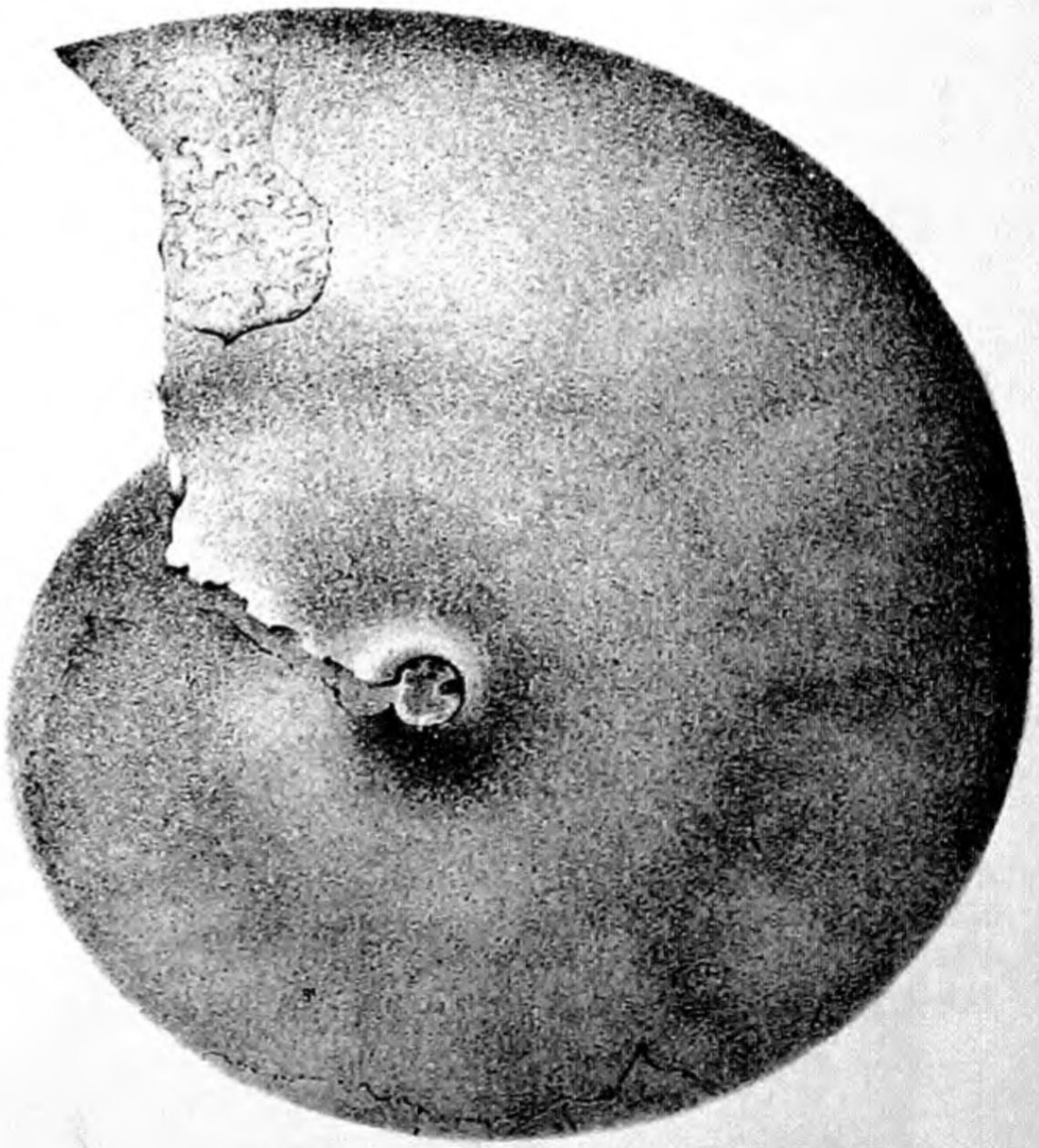

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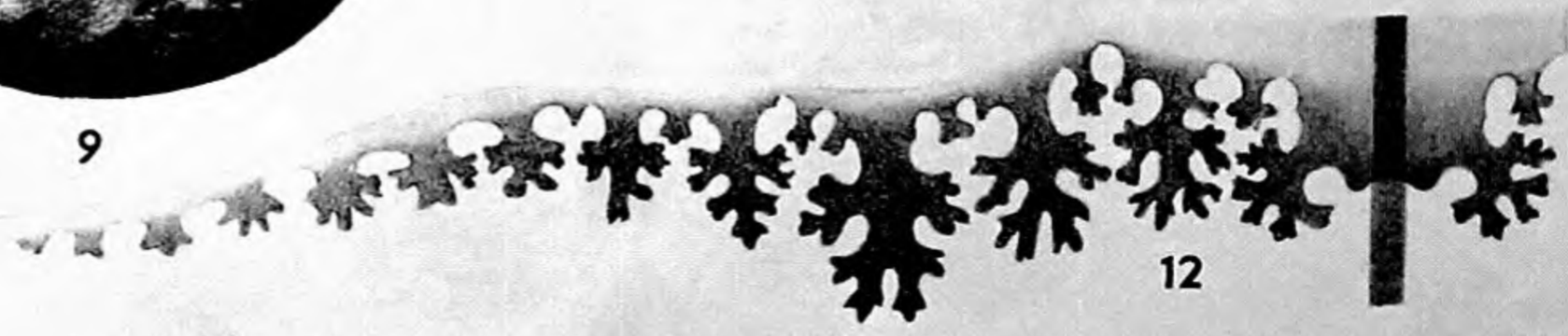

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TURRILITES Lamarck 1801

(**T. costatus*). High spired cones (turriliticones) with angulated whorls, in contact throughout or with only slight loose coiling in old age; costae and two rows of tubercles on each side of median line of whorls; costae often obsolete in old age and only three rows of nodes. **Cret.** (western U. S. A.; Mex.).

T. brazoensis Roemer (**245**—5, 11). **L. Cret.:** Okla., Tex. (Mainstreet, Grayson); Coahuila (Georgetown).

EMPEROCERAS Hyatt 1894

(**E. beecheri*). Young *Hamites*-like, becoming helicoceran in maturity; an important unrolled U. Cret. genus with fairly wide distribution in interior of U. S. A. **U. Cret.**

***E. beecheri** Hyatt (**246**—12, 13). **U. Cret.:** S. Dak.

EXITELOCERAS Hyatt 1894

(**Ancyloceras jenneyi* Whitfield). Helicoceran shells of low spire, with costae and two rows of tubercles, each costa tuberculated; suture varying in complexity; gerontic stage probably with retroversal living chamber. **U. Cret.** (Western Interior).

E. pariense (White) (**246**—7–9). Very loose helicoid spire in youth, with whorls separated; costae sharply rounded, oblique, more than their width apart; a row of tubercles on each side of siphuncle, one to a rib, subspinous when well preserved, but variable; lobes of sutures all smaller than saddles. **Coloradoan:** Tex. (Eagle Ford), Utah.

HELICOCERAS Orbigny 1840

(**H. annulatum*). "Form genus"; aberrant ammonites with shell coiled loosely in a regular conical spiral, with whorls separated at all stages of growth and ornamented by costae and nodes; sutures containing six lobes, the first lateral lobes bifid, and the saddles bifid. **Cret.** (Western Interior).

H. rubeyi Reeside (**246**—11). **Pierre:** S. Dak., Wyo. (Steele), Colo. (Mancos).

H. navarroense Shumard (**246**—10). **U. Cret.:** Tenn. (Ripley), Tex. (Navarro).

PRIONOTROPIS Meek 1876

(**Ammonites woolgari* Mantell). Costae sharply defined in young shells, becoming more distant with increase in whorl size but without intervening spaces occupied by smaller costae; on last whorl, costae and nodes become very prominent and keel is depressed and broken into series of isolated, elongate nodes. **Cret.** (Western Interior; Rocky Mountains; Pacific Coast).

***P. woolgari** (Mantell) (**247**—1, 2). **Benton** and equivalents; S. Dak., Neb., Kan., Tex. (Eagle Ford), Colo., N. Mex.

PRIONOCYCLUS Meek 1872

(**P. wyomingensis*). Costae obscure in very young shells but well developed later, the larger tuberculate ones separated by several smaller, usually nontuberculate, even on last whorl of large adults, where none becomes larger or develops large tubercles; keel continued prominent, not broken into isolated nodes on any of whorls. **Cret.** (Western Interior).

***P. wyomingensis** Meek (**247**—3–5). **Cret.:** Kan., Wyo., Colo. (Carlile), N. Mex. (Benton).

MORTONICERAS Meek 1876

(= TEXANITES Spath 1932)

(**Ammonites vespertinus = A. texanus* Roemer). Conchs compressed, discoid, with wide umbilicus, subquadrate transverse section of whorls; external border broad, bearing a low rounded keel bordered by shallow furrows, which in turn are bordered externally by a row of elongated tubercles; ribs straight, simple or bifurcated, and tuberculate; sutures of few elements — siphonal lobe, three lateral lobes, and antisiphonal lobe; first lateral lobe about as long as siphonal lobe but much longer than second and third; first lateral lobe bifid. **U. Cret.** (Atlantic Coast and Western Interior).

***M. texanum** (Roemer) (**247**—6–8). Characterized by five nodes on each rib. **U. Cret.** (Senonian): Tex. (Austin).

M. shoshonense Meek (**247**—9–16). Has three rows of nodes on each side instead of five as is typical. **Coloradoan:** Wyo. (Niobrara).

ENGONOCERAS Neumayr and Uhlig 1881

(**Ammonites pierdenalis* Buch). Three distinct lines of nodes; venter flat with nodose edges in earlier stages broad, often with zigzag outline in later stages; saddles fairly deep and rounded; lobes with numerous and fairly deep marginals; principal saddles sometimes bifid. **L. Cret.** (Kan., Tex.).

***E. pierdenale** (Buch) (**248**—1–3). **Fredericksburg:** Tex.

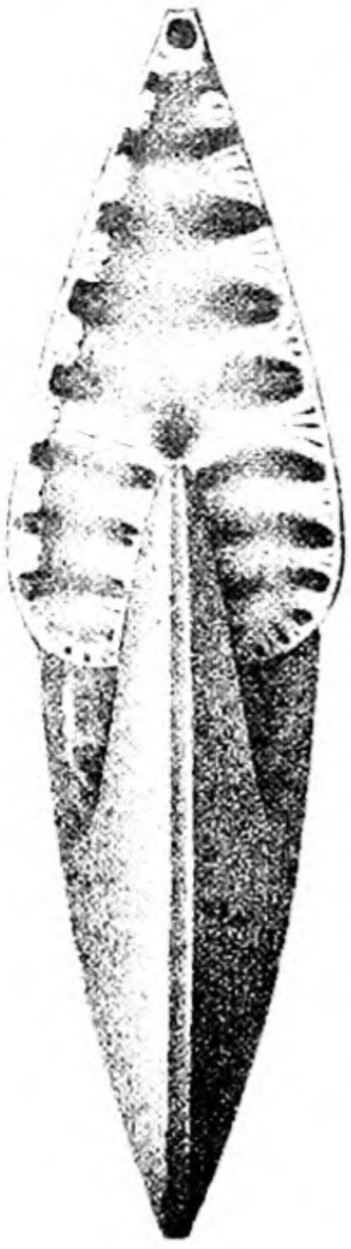
METENGONOCERAS Hyatt 1903

(**M. inscriptum*). Shell with broad folds in some species; usually smooth but rarely faintly nodose; venter in early stages comparatively broad and concave; later narrow but distinctly truncate; still later becomes first acute and then apparently rounded; suture much like that of *Engonoceras* but rarely with divided saddles. **L. Cret.**

PLATE 248

[Figures are x1 and after Hyatt [USGS, M 44] unless otherwise indicated.]

1–3. Engonoceras pierdenale. Two views of a specimen, and suture (x2). **4–6. Metengonoceras inscriptum.** Two views of a specimen, and suture somewhat enlarged. **7–12. Sphenodiscus spp. 7. S. lobatus** (x0.5). **8, 9. S. pleurisepta. 10–12. S. lenticularis** [USGS Ter 9]. Two views of a speciman, and a suturé from another large shell.



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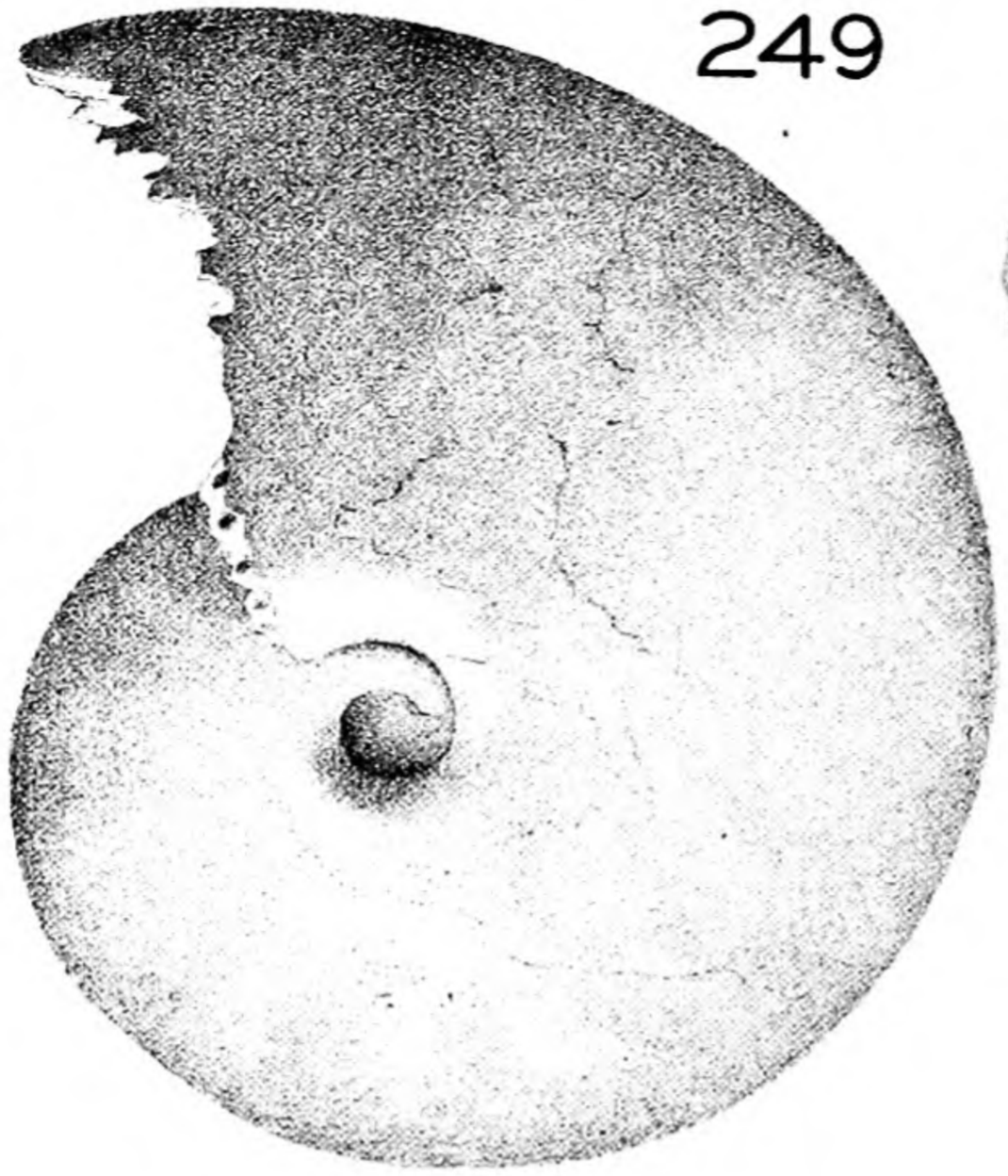

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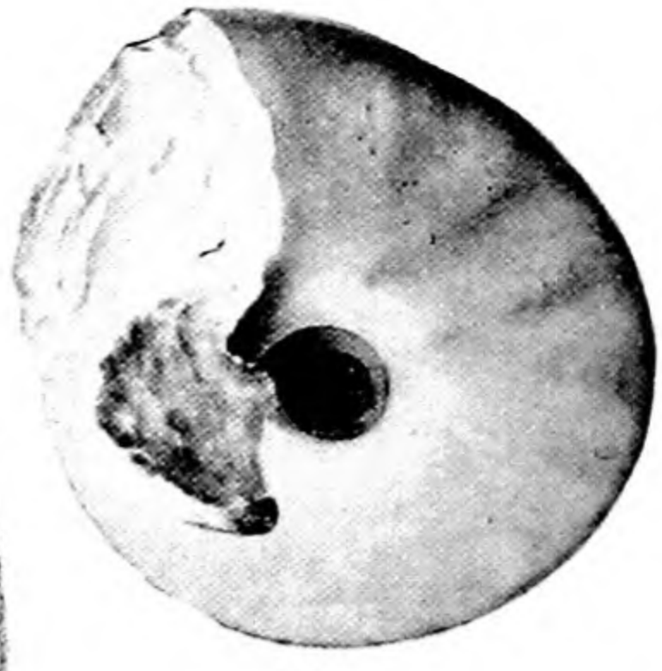

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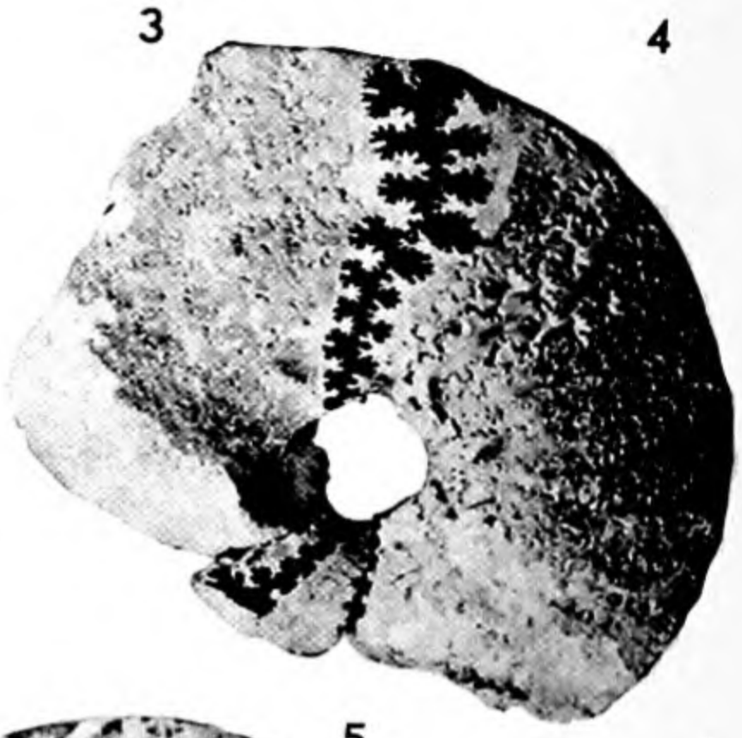

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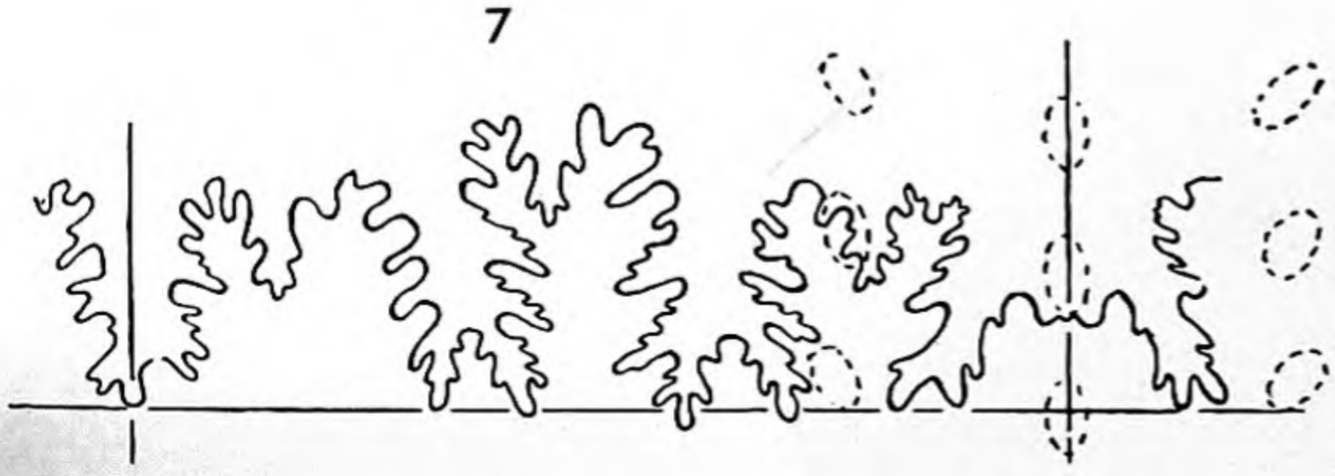

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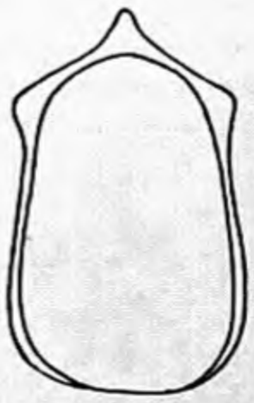

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***M. inscriptum** Hyatt (**248**—4–6). **Fredericksburg:** Tex.

SPHENODISCUS Meek 1872, emend Grossouvre 1908

(**Ammonites lobatus* Tuomey). Adult similar to *Metengonoceras*, but young without grooved venter, the rounded nepionic venter passing directly into an acute neanic, with flattened sides as in the adult; surface smooth or with costae on tubercles. **Cret.**

S. lenticularis (Owen) (**248**—10–12). **Fox Hills:** S. Dak., Wyo., N. Mex. **Maestrichtian:** Nuevo León, Coahuila.

***S. lobatus** (Tuomey) (**248**—7). **U. Cret.:** M. and U. *Exogyra costata* zone of Atlantic and Gulf Coastal Plain.

S. pleurisepta (Conrad) (**248**—8, 9). **U. Cret.:** U. *Exogyra costata* zone of Gulf region.

PLACENTICERAS Meek 1870

(**Ammonites placenta* DeKay). Shell large, discoidal, involute, compressed; whorls stout, rounded in earliest stages; at diameter of a few millimeters higher than wide in cross-section, with flattened venter; all later stages to a large diameter high, compressed, with narrow channeled venter bordered by sharp continuous or nodose keels or with narrow flat venter; very large adults of most species have compressed whorls with narrowly rounded venters; umbilicus narrow in typical forms, about a seventh of shell diameter, with rounded shoulder, gentle inner slope in young and steep in later stages; stout species have a relatively wider umbilicus; sculpture weak; faint ribs in very young stages and none or only low, obscure, coarse ribs in later stages; surface marked by sigmoid striae; tubercles if present weak and scattered; suture in adult with three prominent lateral lobes and six or seven smaller lateral lobes. **U. Cret.** (widespread throughout Western Interior in Canada, U. S. A., and Mex.).

P. guadalupe (Roemer) (**249**—9, 10) **Austin** and equivalents: Gulf region, Tex.

P. intercalare Meek (**249**—6–8). **Pierre:** S. Dak.; Sask., Alta.; Utah, N. Mex.).

P. whitfieldi Hyatt (**249**—1, 2). Differs from its nearest allies very sharply in the much compressed form, smooth whorls with very narrow venter, and peculiar suture. Widely distributed in the **Pierre** and equivalents of the Western Interior; Tex. (Neylandville in *Exogyra cancellata* zone).

***P. placenta** (DeKay) (**249**—5). **U. Cret.:** Del. and N. J. to Tex. (western forms referred to this species now included in **P. meeki.**)

P. planum Hyatt (**249**—3, 4). **U. Cret.:** Ala. and Miss. (Eutaw), S. Dak. (Pierre), Tex. (U. Austin or L. Taylor; San Carlos), N. Mex. (Mancos, Mesaverde), Mont. (Eagle, Telegraph Creek), Wyo. (Telegraph Creek, Steele), Utah (Mancos); Mex.

Subclass Coleoidea (Dibranchia)[1]

Order Belemnoidea. Straight or loosely coiled, internal, calcareous shells consisting of phragmocone, proostracum, and guard. **Trias.–Recent.**

ATRACTITES Guembel 1861

(**Orthoceratites alveolaris* Quenstedt). Phragmocone long, guard short; septa simple, concave; siphuncle marginal, siphonal funnels marked; protoconch calcareous. **Trias., L. Jura.** (western U. S. A.).

A. philippii Hyatt and Smith (**250**—1, 2). Long and slender, circular in section; guard thick and massive, not extending far beyond shell and absent in young shells. **U. Trias.:** Cal. (Hosselkus).

A. solidus Smith (**249**—13). **M. Trias.:** Nev.

CYLINDROTEUTHIS Bayle 1878

(**Belemnite puzosianus* Orbigny). Guards with shallow ventral groove extending from apex a short distance aperturally. **U. Jura., L. Cret.** (Alaska to Cal.).

C. skidegatensis (Whiteaves) (**250**—3–5). Faint apical groove; alveolar cavity about half entire guard length; apex of guard and phragmocone eccentric. **L. Cret.:** B. C. (Queen Charlotte).

PACHYTEUTHIS Bayle 1878

(**Belemnites excentralis* Young and Bird). Guard very slender in young; short and stumpy in adult, with marked eccentricity visible in section. **Jura.** (Western Interior).

P. densus (Meek) (**250**—6–8). Guard large, up to 10 cm long below phragmocone and nearly 25 mm in diameter; subcylindrical, ovate or oval in section; sometimes obscurely subquadrangular; phragmocone short, rapidly expanding; apex subcentral in guard; septa numerous, regularly concave. **U. Jura.:** S. Dak. Wyo., Utah.

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[1]**Buelow-Trummer, E. V.,** Cephalopoda dibranchiata: Fos Cat, pars 11: 1-313, 1920. **Crickmay, C. H.,** The genotype of *Belemnites*; with a synopsis of North American species of Belemnoidea: *Can Field Nat* 47: 12–15, 1933. **Whiteaves, J. F.,** On some remains of a *Sepia*-like cuttlefish from the Cretaceous rocks of the South Saskatchewan: *Can Rec Sc* 7: 459–461, 1898.

PLATE 249

[Figures are x1 and after Hyatt [USGS, M 44] unless otherwise indicated.]

1–10. Placenticeras spp. **1, 2. P. whitfieldi** [USGS Ter 9]. Two views of a small specimen. **3, 4. P. planum** (x0.5). **5. P. placenta. 6–8. P. intercalare.** Suture (x2), and two views of a specimen. **9, 10. P. guadalupe** (x0.3). **11, 12. Phlycticrioceras oregonense** [USGS, PP 150]. Suture (x2), and cross section of type (also see **244**—1, 2). **13. Atractites solidus** [USGS, PP 83]. Longitudinal section (x2) showing phragmocone.

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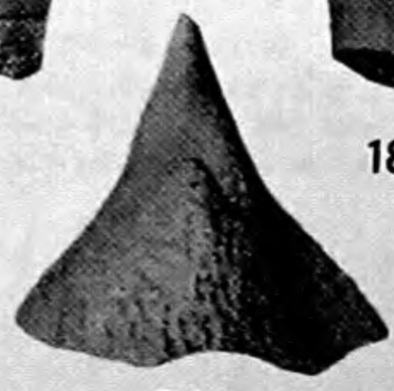

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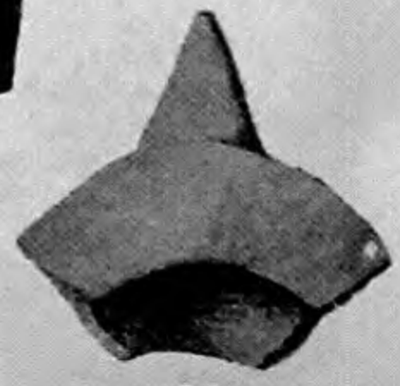

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OXYTEUTHIS Stolley 1911

(**Belemnites brunsvicensis* Strombeck). Like *Cylindroteuthis*, but without ventral furrow. **L. Cret.** (Alaska to Cal.).

O. tehamaensis (Stanton) (**250**—11,12). **Knoxville:** Cal.

AULACOTEUTHIS Stolley (1911) 1919

(**Belemnites absolutiformis* Sin(t)zow). Like *Cylindroteuthis*, but with longer and deeper ventral groove. **U. Jura., L. Cret.** (Alaska to Cal.).

A. impressus (Gabb) (**250**—9, 10). Large, robust, tapering for about one-fourth of length to blunt point; ventral side with wide, deep furrow, deepest at about apex of phragmocone and fading to end of guard. **L. Cret.:** Cal. (Knoxville, Horsetown).

BELEMNITELLA Orbigny 1840

(**Belemnites mucronatus* Schlotheim). Guard cylindrical, with short deep ventral furrow falling short of alveolar margin; phragmocone inserted in guard which ends in a mucronate point. **Cret.** (widespread in U. S. A. and western Canada).

B. americana (Morton) (**250**—13–18). Margin of alveolar cavity very thin, but that and mucronate point often destroyed; cavity about one-third guard length; proportionally more elongate than the European **B. mucronatus. U. Cret.:** Atlantic and Gulf Coastal Plain.

Order Sepioidea. Shell internal and consisting of a horny or calcareous spatulate pen, corresponding to proostracum of the Belemnoidea; guard and phragmocone undifferentiated. **Jura.–Recent.**

BELOSEPIA Voltz 1830

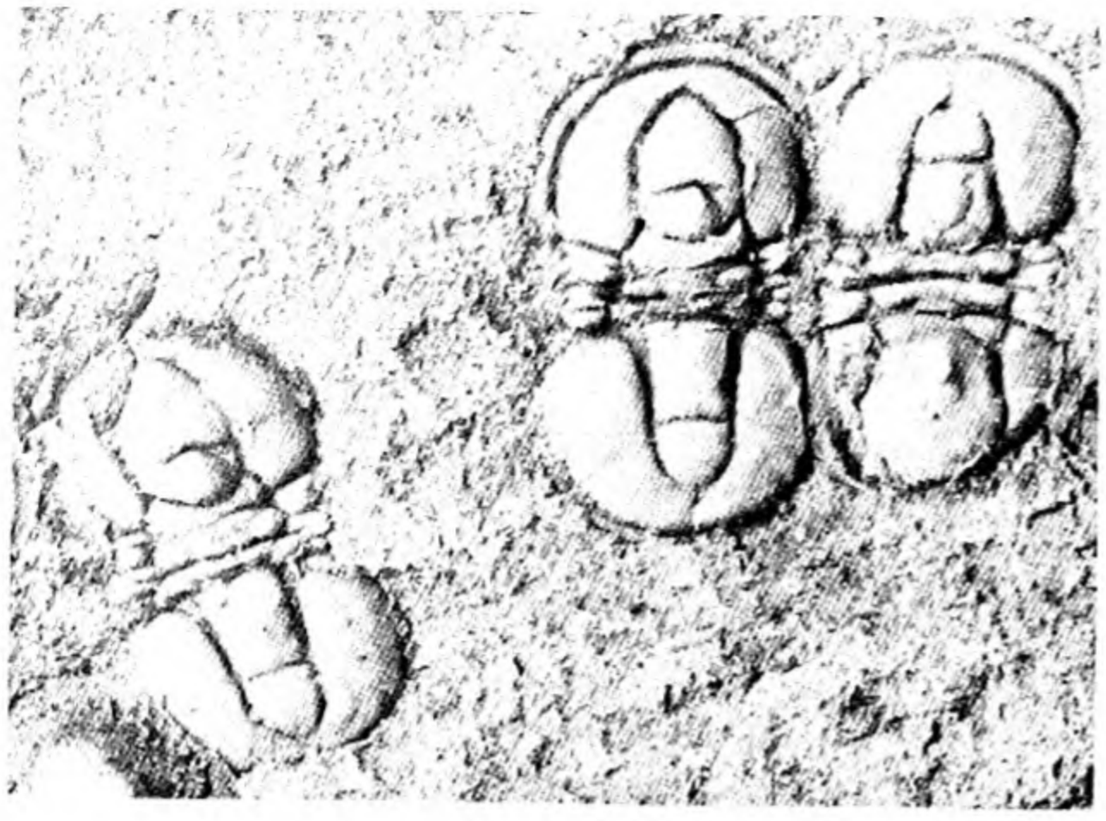
(**Beloptera sepioidea* Blainville). Posterior portion of proostracum or pen ending in bent spine, and thickened anteriorly, where it is laterally expanded; a conical alveolus marks position of phragmocone. **Eoc.**

B. ungula Gabb (**250**—19–21). Conical expansion of pen, much thickened at anterior end, which is strongly roughened; alveolar cavity profound. **Claiborne:** Ala., Tex.

PLATE 250

[Figures are x1 unless otherwise indicated.]

1, 2. Atractites philippii [USGS, PP 40]. Specimen showing phragmocone and guard; phragmocone (x1.3) of another specimen. **3–5. Cylindroteuthis skidegatensis** [CGS, Mes Fos]. Specimen showing phragmocone and guard; guard, with cross section, near apex of phragmocone (x0.7). **6–8. Pachyteuthis densus** [USGS Rocky Mts, G Bl Hills]. 6: Large specimen broken off near base of alveolar cavity. 7: Longitudinal section of another specimen showing phragmocone in place, with some septa preserved. 8: Upper part of 6, in cross section, showing eccentricity of alveolar cavity. **9, 10. Aulacoteuthis impressus** [USGS, B 133]. Cross section just below phragmocone of medium sized specimen; ventral view of a somewhat slender shell. **11, 12. Oxyteuthis tehamaensis** [USGS, B 133]. Cross section and side view of type. **13–18. Belemnitella americana** [USGS, M 18]. 13, 14: Two views of a large shell. 15: Longitudinal section of preceding. 16, 17: Views of a fragmental phragmocone showing septal markings. 18: Filling of alveolar cavity of another specimen. **19–21. Belosepia ungula** (x2) [An Géol et Pal 12]. Three views of pen, which is thickened anteriorly where it is laterally expanded.



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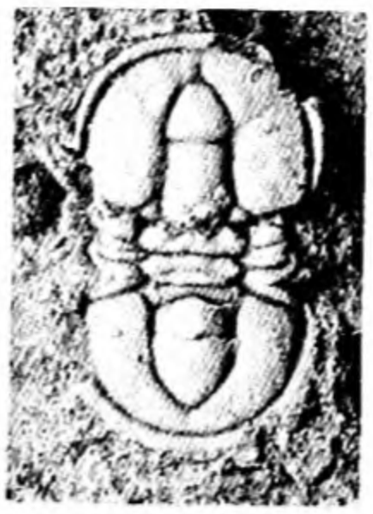

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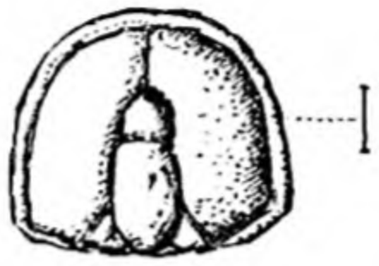

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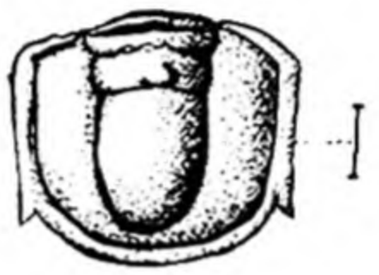

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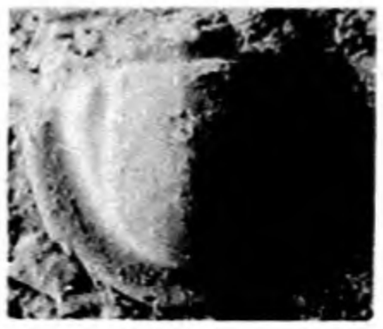

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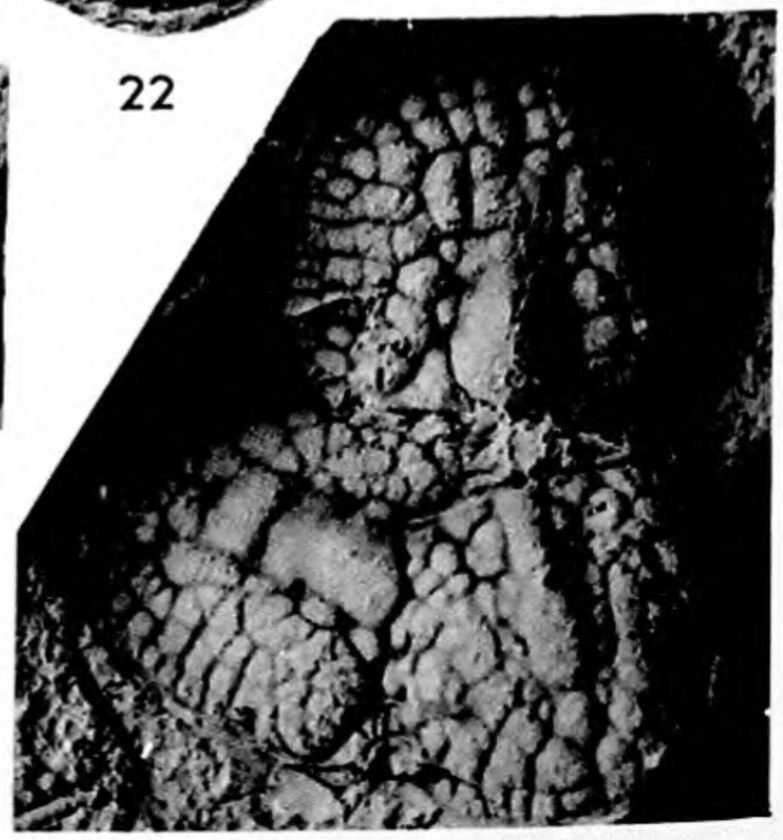

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CHAPTER XI

PHYLUM ARTHROPODA[1, 2]

Arthropods are transversely segmented animals with mouth and anus at opposite ends of an elongate body which is attached by muscles to the inside of a chitinous exoskeleton or a calcareous shell. The phylum is subdivided as follows (divisions ranking lower than subclass will appear in the later discussion; * indicates a questionable fossil record):

Class **Crustacea**
- Subclass **Agnostia**
- Subclass **Trilobita**
- Subclass **Homopoda**
- Subclass **Xenopoda**
- Subclass **Archaeostraca**
- Subclass **Branchiopoda**
- Subclass **Ostracoda**
- Subclass **Cirripedia**
- Subclass **Malacostraca**

Class ***Onychophora**
Class **Myriapoda**
Class **Insecta**
Class **Arachnida**
- Subclass **Merostomata**
- Subclass **Embolobranchiata**

CLASS CRUSTACEA[3]

Crustacea are mainly aquatic, carnivorous arthropods with the body inclosed by a protective and supporting chitinous shell which becomes thickened with calcium carbonate where no movement is required. The body is divisible into head (*cephalon*), *thorax*, and *abdomen*. The five anterior segments are fused with the front of the body to form the head, several thoracic segments may be fused with the head to form a *cephalothorax*, or a dorsal shield may project from the posterior margin of the head to form a *carapace*. Certain nontrilobitan crustaceans commonly are found fossil, often in concretions; others occur rarely as fossils; and certain groups appear to have left no fossil record whatsoever.

Fossil and living Crustacea are typically characterized by the presence of tactile organs as the first

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[1] The authors are greatly indebted to Dr. P. E. Raymond, who was most cooperative at all times and in many ways during the revision of this phylum. Specific acknowledgments will be made in the appropriate places.

[2] Many groups of arthropods are described and illustrated in the following State and Federal reports: *Ala G S*, S Rp 14; *Pal Cal* 1, 2; *Ill G S* 3–5; *Ind G S* 13, 28; *Kan G S* 6; *Md G S, Camb., Ord.*, etc.; *Minn G S* 3 (2); *Mo G S* 6, 24; *Pal N J* 3; *Pal N Y* 1–7; and numerous Annual Reports, Bulletins, Monographs, Professional Papers and other publications of the U. S. Geological Survey. In addition, some important articles are included in the Bulletins and Proceedings of the U. S. National Museum and in the Smithsonian Miscellaneous Collections.

For Canada, the chief sources are the numerous publications of the Geological Survey of Canada and of the several Provincial Surveys, and certain periodicals, e.g. Royal Society of Canada, Proceedings and Transactions; Bulletins of the Natural History Society of New Brunswick; and Canadian Record of Science.

[3] **Beecher, C. E.,** Ceratiocaridae from Chemung and Waverly of Pennsylvania: *Pa G S, PPP:* 1–22, il, 1884; Revision of the Phyllocarida from Chemung and Waverly of Pennsylvania: *GSL*, QJ 58: 441–449, 1902. **Clarke, J. M.,** Paleozoic crustaceans [*Pseudoniscus* and Phyllocarida]: *N Y St Mus*, An Rp 54: 83–124, il, 1902. **Cooper, C. L.,** A crustacean fauna from the Woodford of Oklahoma: *JP* 6: 346–352, il, 1932. **Eller, E. R.,** *Echinocaris* from Devonian of New York: *Carnegie Mus*, An 24 (8): 263–274, il, 1935. **Raymond, P. E.,** *Leanchoilia* and other mid-Cambrian Arthropoda: *MCZ (Harvard)*, B 76: 205–230, 1935. **Resser, C. E.,** New Lower and Middle Cambrian Crustacea: *USNM*, Pr 76 (9): 1–18, il, 1929. **Ruedemann, R.,** *Apus* in Permian of Oklahoma: *JG* 30: 311–318, il, 1922. **Van Straelen, V.,** and **Schmitz, G.,** Crustacea Phyllocarida (= Archaeostraca): *Fos Cat*, pars 64 (*in press*). **Ulrich, E. O.,** and **Bassler, R. S.,** Cambrian Conchostraca: *USNM*, Pr 78 (4): 1–130, il, 1931. **Vogdes, A. W.,** A classed and annotated bibliography of Paleozoic Crustacea, 1698–1892, to which is added a catalogue of North American species: *Cal Ac Sc*, Oc P 4: 1–412, 1893; Supplement: *Cal Ac Sc*, Pr (2) 5: 53–76, 1895; Paleozoic Crustacea; the publications and notes on the genera and species during the past twenty years, 1895–1917: *San Diego Soc N H*, Tr 3: 1–141, 1917; Paleozoic Crustacea; Pt. I, Bibliography of Paleozoic Crustacea; Pt. II, List of genera and subgenera of Trilobita; Pt. III, A summary of *Cybele: San Diego Soc N H*, Tr 4: 1–154, il, 1925.

PLATE 251

[Photographs furnished by Howell are indicated by BFH; those by Resser, CER].

1, 2, 19. Agnostus montis (x6) [CER]. Specimens showing variations in preservation. **3, 4. Proagnostus bulbus** (x6) [GSA, SP 15; CER]. Two nearly complete specimens showing variation in preservation. **5, 6. Pseudagnostus josepha** (x6) [CER]. **7, 8. Tomagnostus fissus** (x4) [WFIS, B 10 (2)]. **9, 10. Homagnostus obesus** (x4) [WFIS, B 10 (2)]. **11, 12. Acadagnostus acadicus** [USGS, B 10]. **13, 14. Agnostus regulosus** (x4) [R Soc Can, Tr 9]. **15. Eoagnostus roddyi** (x6) [GSA, B 49; CER]. Holotype. **16, 17. Agnostus interstrictus** [USGS, B 30]. Top and side views of type. **18. Oedorhacus typicalis** (x6) [GSA, SP 15; CER]. **19.** See 1 and 2 above. **20. Ptychagnostus punctuosus** (x6) [BFH]. **21, 22. Triplagnostus lomondensis** (x4) [WFIS, B 10 (2)]. **23, 24. Condylopyge rex** (x2) [Barrande: Syst Sil]. **25–27. Kormagnostus simplex** (x6) [GSA, SP 15; CER]. Cranidia and pygidia on a slab; cranidium; pygidium, partly exfoliated. **28. Glyptagnostus angelini** (x6) [CER].

pair of appendages, and rather universal evidence of actual or former presence of biramous limbs. Such a characterization necessitates considerable modification of the generally accepted classification of Crustacea, particularly as regards the earlier (Cambrian) fossil representatives. The classification here used is that recently suggested by Raymond (1935), who pointed out the fact that whereas the Cambrian crustaceans are related to more recent animals of the same general form, they should not be placed in the same subclasses with recent or living crustaceans because they possess trilobitan rather than crustacean limbs.

Subclass Agnostia[1]

Small, extinct Crustacea consisting of nearly equal head and abdominal shields, separated by two thoracic segments; eyeless; head shield usually with a completely outlined glabella which, in most species, has a frontal lobe; a median furrow may extend from glabella to front margin; most species have basal side lobes at rear of glabella; abdominal shield usually with short axis. **L. Camb.–Ord.**

EOAGNOSTUS Resser and Howell 1938

(**E. roddyi*). Dorsal furrow shallow; frontal and basal lobes lacking; dorsal furrow in abdominal shield moderately deep, axis large, without transverse furrows. **L. Camb.** (N. Appalachians).

***E. roddyi** R and H (**251**—15). **Kinzers:** Pa.

CONDYLOPYGE Hawle and Corda 1847

(**Battus rex* Barrande). Anterior lobe of glabella subtriangular, wider than main lobe; axial lobe of pygidium expanded and evenly rounded at rear; test smooth, without spines on either shield. **M. Camb.**

***C. rex** (Barrande) (**251**—23, 24; **276**—17, 18). **M. Camb.:** Newf (Long Pond, Kelligrew Brook).

TRIPLAGNOSTUS Howell 1935

(**Agnostus gibbus* Linnarsson). Anterior lobe of glabella subtriangular; medial furrow present; axial lobe of pygidium long and bluntly pointed at rear; test smooth, without spines. **M. Camb.**

T. lomondensis Howell (**251**—21, 22). Front end of anterior glabellar lobe bluntly pointed; pleural lobes widely confluent behind axial lobe of pygidium. **M. Camb.:** N. B. (Hastings Cove).

TOMAGNOSTUS Howell 1935

(**Agnostus fissus* Linnarsson). Front end of anterior lobe of glabella indented by a furrow lying on axial line; rear lobe along pygidial axis bluntly triangular; no median furrow or spines. **M. Camb.**

***T. fissus** (Linnarsson) (**251**—7, 8). **M. Camb.:** Newf. (Long Pond); N. B. (Porter Road).

[1] Drs. B. F. Howell and C. E. Resser prepared most of the generic descriptions and furnished a number of the illustrations here reproduced. It is our pleasant duty to acknowledge this valuable assistance.

PTYCHAGNOSTUS Jaekel 1909

(**Agnostus punctuosus* Angelin). Front lobe of glabella and rear lobe along pygidial axis triangular; cheeks furrowed; cheeks and pleural lobes tuberculate; no spines. **M. Camb.**

***P. punctuosus** (Angelin) (**251**—20). **Kelligrew Brook:** Newf.

AGNOSTUS Brongniart 1822

(**Entomolitus paradoxus* γ *pisiformis* Linnaeus). Agnostia with anterior glabellar lobe slightly pointed in front; a medial furrow present; rear lobe of pygidial axis bluntly rounded at rear, with the pleural lobes confluent behind it; pygidium with small spines. **Camb.** (N. America).

A. interstrictus White (**251**—16, 17). Thorax narrower than head or abdominal shield; differs from **A. pisiformis** in the almost total absence of basal glabellar lobes, in the presence of a slight folding back of the marginal rim at the anterolateral angles of pygidium, and in less definite segmentation of the pygidial axis. **M. Camb.:** Utah, Nev.

"A." montis Matthew (**251**—1, 2, 19). **M. Camb.:** B. C. (Stephen); closely allied species are common throughout N. America.

A. regulosus Matthew (**251**—13, 14). **U. Camb.:** N. B. (Agnostus Cove).

ACADAGNOSTUS Kobayashi 1939

(**Agnostus acadicus* Dawson). Agnostia with anterior glabellar lobe rounded in front and posterior lobe of pygidial axis pointed at rear, separating the pleural lobes. **M. Camb.** (N. America; Europe).

***A. acadicus** (Dawson) (**251**—11, 12). **M. Camb.:** N. B. (Fossil Brook).

HOMAGNOSTUS Howell 1935

(**Agnostus pisiformis obesus* Belt). Anterior lobe of glabella somewhat, but not acutely, pointed at front end; rather faint medial furrow on cephalon; large pygidial axis with semiglobular rear lobe. **U. Camb.**

***H. obesus** (Belt) (**251**—9, 10). **U. Camb.:** Newf. (Elliott Cove); N. B. (Johannian).

GLYPTAGNOSTUS Whitehouse 1936

(**G. toreuma*). Carapace surface characterized by a deeply impressed network which largely obliterates the glabella and pygidial axis. **U. Camb.** (S. Appalachians).

G. angelini Resser (**251**—28). **Nolichucky:** Ala.

KORMAGNOSTUS Resser 1938

(**K. simplex*). Dorsal furrow deep, anterior glabellar lobe lacking; very large pygidial axis with two faint transverse furrows; wide flange on both shields. **U. Camb.** (eastern and central N. America).

***K. simplex** Resser (**251**—25–27). **Nolichucky:** S. Appalachians.

OEDORHACHIS Resser 1938

(**O. typicalis*): Head shield typically agnostian, without median furrow; pygidial axis large, expanding in circular fashion behind rear transverse furrow; lateral spine present. **U. Camb.** (eastern and central N. America).

***O. typicalis** Resser (**251**—18). **Nolichucky:** Ala.

PROAGNOSTUS Butts 1926

(**P. bulbus*). Cranidium typically agnostian, with median furrow; pygidial axis one-third width of pygidium, slightly expanded behind rear transverse furrow, and with marginal spines. **U. Camb.** (S. Appalachians).

***P. bulbus** Butts (**251**—3, 4). **Nolichucky:** Ala.

PSEUDAGNOSTUS Jaekel 1909

(**Agnostus cyclopyge* Tullberg). Cranidium typically agnostian with median furrow; pygidial axis broad and short; characterized by strong lateral furrows diverging from ends of rear transverse furrow. **U. Camb.** (worldwide).

P. josepha (Hall) (**251**—5, 6). **Franconia** (Conaspis zone): U. Mississippi Valley.

Subclass Trilobita[1,2]

Extinct marine Crustacea wholly confined to Paleozoic rocks; body covered by dorsal shield which is longitudinally divided into three parts The anterior part is the *cephalon;* it usually is semi-

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[1] It is our pleasant duty to acknowledge the valuable assistance rendered by the following: Dr. Josiah Bridge furnished geographic distribution data for several genera and also gave us original prints of several species figured in the report on the Eminence Quadrangle (*Mo G S* 24). Dr. B. F. Howell and Mr. N. M. Denson helped to prepare generic descriptions for many Cambrian genera, and the former furnished several illustrations. Dr. P. E. Raymond helped in the final revision of all Cambrian genera, prepared new descriptions for several post-Cambrian genera, assisted in selecting illustrations for many of the species, collaborated in preparing the diagrammatic explanatory figures on plate **252**, and suggested the grouping of genera followed on the plates. Dr. C. E. Resser assisted in the description of numerous Cambrian genera, aided in many ways in the compilation of stratigraphic data, and furnished a great many photographs, some of specimens originally figured by Walcott. Dr. J. M. Weller revised the material on the late Paleozoic (Miss.–Perm) trilobites, and kindly loaned us a number of negatives from which most of the illustrations on plate **275** were obtained.

In addition, we wish to acknowledge the valuable assistance of the following specialists: Drs. D. M. Delo, Christina Lochman, and F. B. Phleger, Jr., and Mr. G. O. Raasch. Each helped in an important way, either by revising and expanding descriptive matter or by furnishing illustrations.

Illustrations furnished by the above-mentioned persons are specifically acknowledged in the proper places.

[2] **Barton, D. C.,** A revision of the Cheirurinae, with notes on their evolution: *Wash U Stud* 3 (1): 101–152, il, 1915. **Bridge, J.,** Redescription of Ferdinand Roemer's Paleozoic types from Texas: *USGS*, PP 186: 239–271, il, 1937. **Clarke, J. M.,** Lower Silurian [Ord.] trilobites of Minnesota: *Minn G S* 3 (2): 695–759, il, 1897. **Cooper, G. A.,** New species [Trilobita] from Upper Ordovician of Percé: *AJS* (5) 20: 365–392, il, 1930. **Cox, I. H.,** Richmond trilobites from Akpatok Island: *G Mag* 70: 359–373, 1933. **Deiss, C.,** Cambrian stratigraphy and trilobites of northwestern Montana: *GSA*, SP 18: 1–135, il, 1939. **Delo, D. M.,** A revision of the Phacopid trilobites: *JP* 9: 402–420, il, 1935; Phacopid trilobites of North America: *GSA*, SP 29: 1–135, il, 1940. **Foerste, A. F.,** Notes on *Isotelus, Acrolichas, Calymene,* and *Encrinurus: DUB, JSL* 19: 65–82, il, 1919; Generic relations of American Ordovician Lichadidae: *AJS* (4) 49: 26–50, il, 1920. **Gheyselinck, R. F. C. R.,** Permian trilobites from Timor and Sicily, with a revision of their nomenclature and classification: Amsterdam, Scheltema & Holkema's Boekhandel, p. 1–108, il, 1937 (reviewed in *JG* 47: 443–444, 1939). **Green, J.,** A monograph of the trilobites of North America, p. 1–93, il, 1832, Philadelphia; A supplement to the preceding, p. 1–24, 1835, Philadelphia. **Hall, J.,** Descriptions of many new genera and species in *Pal N Y* 1 (Ord.), 2 (Sil.), 3 (Dev.) and 7 (Dev.); Fauna of the Potsdam of the upper Mississippi valley: *N Y St Cab*, An Rp 16: 119–222, il, 1863. **Hayes, A. O.,** and **Howell, B. F.,** Geology of St. John, New Brunswick: *GSA*, SP 5: 1–146, il, 1937. **Howell, B. F.,** Cambrian *Paradoxides* beds of northwestern Vermont: *Vt G S*, Rp 16: 249–273, il, 1929; Faunas of the Cambrian *Paradoxides* bed at Manuels, Newfoundland: *B Am Pal* 11 (43): 1–140, il, 1925; Cambrian *Centropleura vermontensis* fauna of northwestern Vermont: *GSA*, B 48: 1147–1210, 1937. **Howell, B. F.,** and **Lochman, C.,** Succession of late Cambrian faunas in the Northern Hemisphere: *JP* 13: 115–122, 1939. **Howell, B. F.,** and **Duncan, D.,** Middle-Upper Cambrian transition faunas of North America: *Wag Free Inst Sc*, Tr 14: 1–11, il, 1939. **Kobayashi, T.,** The Cambro-Ordovician formations and faunas of South Chosen: *Imp U Tokyo, J Fac Sc* (2) 3 (8, 9), 1934; The *Briscoia* fauna of the Upper Cambrian in Alaska, with Upper Cambrian trilobites from Montana and Nevada: *Jap J G and Geogr* 12: 39–57, il, 1935; Cambrian and Lower Ordovician trilobites from northwestern Canada: *JP* 10: 157–167, il, 1936; Upper Cambrian fossils from British Columbia: *Jap J G and Geogr* 15: 149–192, il, 1938; On the Agnostids, Pt 1: *Imp U Tokyo, J Fac Sc* (2) 5 (5), 1939 (also see Supplementary notes on the Agnostida: *J G Soc Japan* 46 (554): 577–580, 1939). **Lochman, C.,** New trilobite genera from Bonneterre (U. Camb.) of Missouri: *JP* 10: 35–43, il, 1936; Middle and Upper Cambrian faunas of western Newfoundland: *JP* 12: 461–477, il, 1938; Upper Cambrian faunas of Cap Mountain formation of Texas: *JP* 12: 72–85, 1938; Fauna of the basal Bonneterre (U. Camb.) of southeastern Missouri: *JP* 14: 1–53, il, 1939. **Mason, J. F.,** Cambrian faunal succession in Nevada and California: *JP* 12: 287–294, 1938. **Matthew, G. F.,** Fauna of the St. John group [New Brunswick] (many papers in *Can Rec Sc* and *R Soc Can*, Pr and Tr, 1884–1916; see *USGS*, B 746); The *Protolenus* fauna: *N Y Ac Sc*, Tr 14: 101–153, il, 1895; Report on the Cambrian rocks of Cape Breton: *CGS*, p 1–246, il, 1903. **Miller, B. M.,** Cambrian trilobites from northwestern Wyoming: *JP* 10: 23–34, il, 1936. **Phleger, F. B., Jr.,** Lichadian trilobites: *JP* 10: 593–616, il, 1936. **Poulsen, C.,** The Cambrian, Ozarkian, and Canadian faunas of northwest Greenland: *Med om Grønland*, Bd 70: 233–343, il, 1927; The Lower Cambrian faunas of east Greenland: *Med om Grønland*, Bd 87 (6), Copenhagen; Univ., Mus. minéralogie et géol, Comm paléont 44: 1–66, il, 1932. **Raymond, P. E.,** Trilobites of the Chazy: *Carnegie Mus*, An 3: 328–386, il, 1905; II, Asaphidae from the Beekmantown: *Carnegie Mus*, An 7: 35–44, il, 1910; III, New and old species from the Chazy: Idem: 60–80, il, 1910; Trilobites of the Chazy of Vermont: *Vt G S*, Rp 7: 213–248, il, 1910; Revision of species referred to *Bathyurus: CGS, Victoria Mem Mus*, B 1: 51–69, il, 1913; New and old Silurian trilobites from Wisconsin: *MCZ (Harvard)*, B 60: 3–41, il, 1916; New Upper Cambrian and Lower Ordovician trilobites from Vermont: *Boston Soc N H*, Pr. 37: 389–406, il, 1924; *Vt G S* 14: 137–203, il, 1924; Trilobites of Lower Middle Ordovician of eastern North America: *MCZ (Harvard)*, B 67: 1–180, il, 1925; Upper Cambrian and Lower Ordo-

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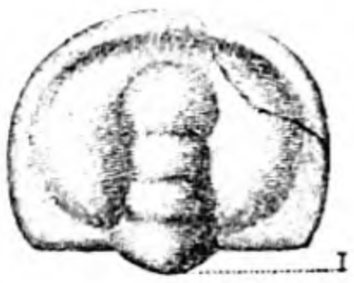

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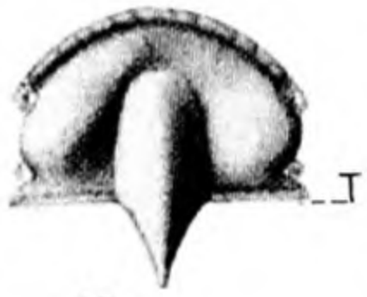

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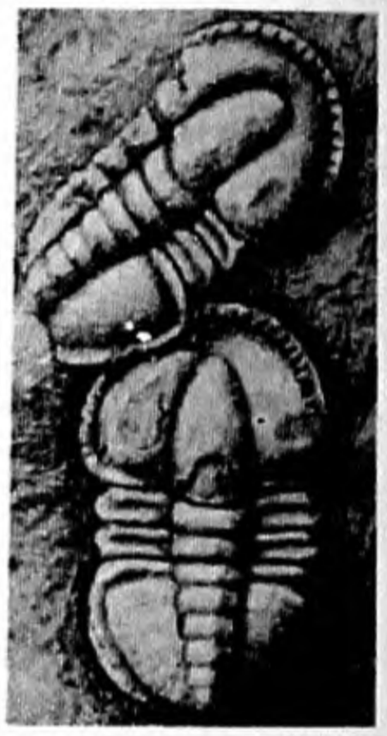

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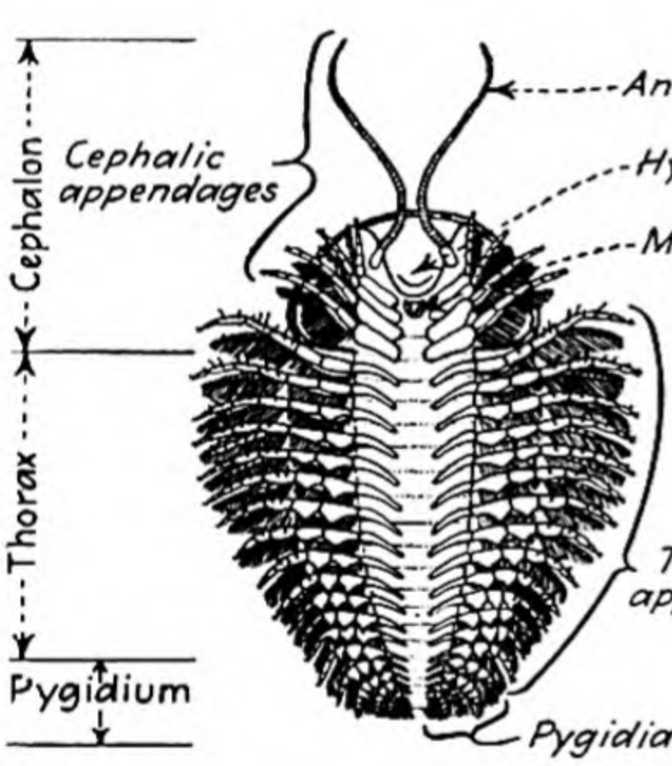

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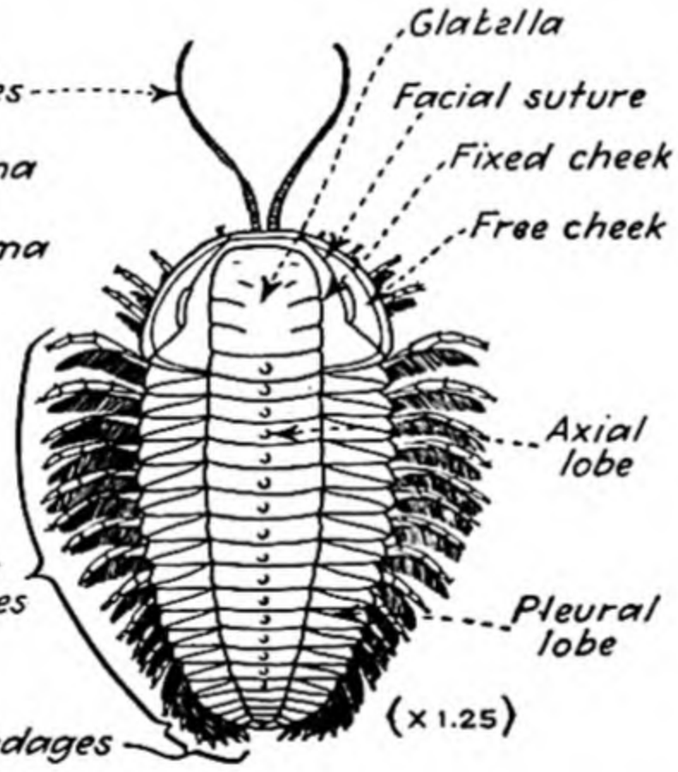

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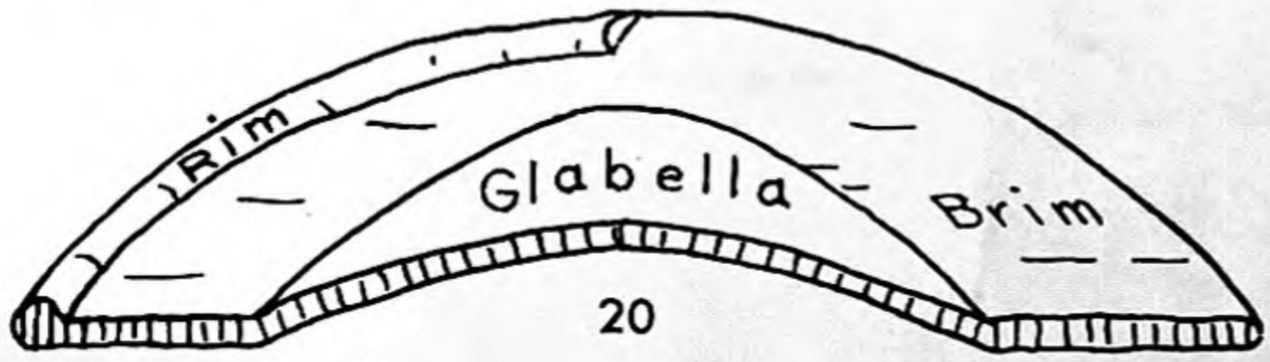

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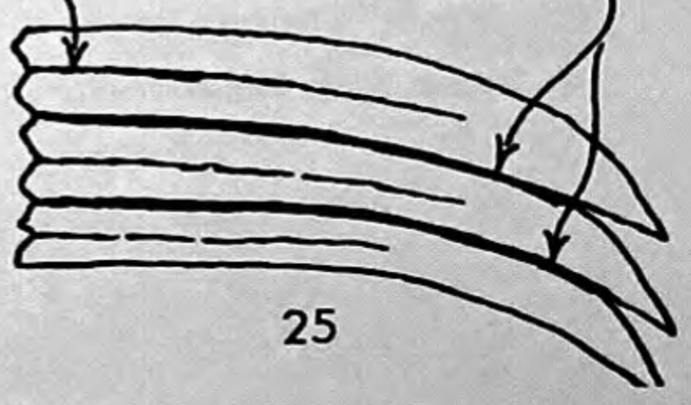

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circular with a straight posterior border, but many genera have genal spines developed at junction of lateral and posterior borders. The central of the three cephalic lobes is the most prominent and constitutes the *glabella;* it is variable in outline, bounded laterally and anteriorly by the *circumglabellar furrow*; and more or less divided by transverse furrows or pairs of marginal furrows (*glabellar furrows*). The posterior furrow, designated *occipital*, lies just in front of the *occipital ring*, which is just anterior to the first thoracic segment.

On each side of the glabella is a pair of cheeks, divided by the facial suture into *fixed cheeks* (those next to the glabella) and *free cheeks* (the outermost or movable portions). Either of the cheeks may be prolonged into genal spines. The compound eyes are situated on the free cheeks and are overshadowed by more or less prominent *palpebral lobes*, which are lateral lobes from the fixed cheeks. The facial suture, therefore, passes between the eyes and palpebral lobes and when, as is often the case, the free cheeks become detached after moulting or death, only the palpebral lobes remain on the central portion of the cephalon (= the *cranidium*, which consists of glabella and fixed cheeks) to indicate the former position of the eyes. The anterior end of the palpebral lobe is often bound to the glabella by the *ocular ridge*.

The frontal border of the cephalon is often distinctly marked and is designated the *brim;* it may be convex, flat or concave, and may have a *rim* (see pl 252). This area is also designated *preglabellar*. At the margin it is folded down and back, making the *doublure*, which continues backward and often is produced into hollow or solid genal spines. Attached to the anterior portion of the doublure is the lip or *hypostoma*, which is often found separate; this structure is homologous with the crustacean upper lip.

The middle part of the test is the *thorax*, which consists of numerous segments articulating with each other, commonly permitting enrollment by the animal. Each thoracic segment is divided by two dorsal furrows into a central axial lobe and two lateral pleural lobes or pleura.

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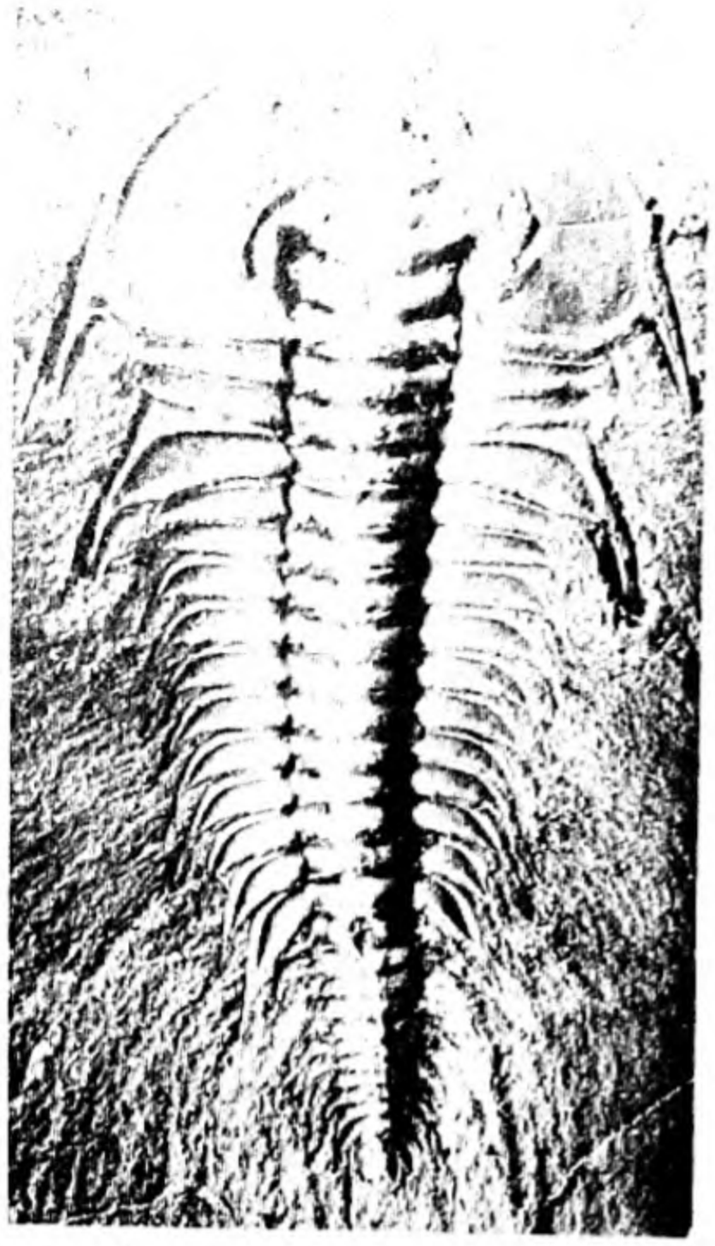
PLATE 252

[Photographs furnished by Howell are indicated by BFH; those by Resser, CER.]

1. Eodiscus punctatus (x6) [CER]. **2, 3. Dawsonia lobatus** [USGS, B 30]. Cephalon and pygidium, both greatly enlarged. **4–6. Eodiscus speciosus** (x3) [CER]. Cephalon, pygidium, and complete specimen. **7–9. Pagetia bootes.** 7: Nearly complete specimen (x6) [CER]. 8, 9: Side view in outline, and retouched dorsal view of a partly imbedded specimen (x8) [SMC 64 (5)]. **10–12. Dawsonia dawsoni** (x9) [BFH]. Complete specimen viewed obliquely; cephalon with the typical spine; pygidium. **13–15. Pagetia clytia** [SMC 64 (5)]. Cephalon and pygidium, both greatly enlarged; two specimens (x6). **16. Weymouthia nobilis** (x4) [Conn Ac, M 7]. **17, 18. Triarthrus beckii** [after Twenhofel and Shrock: "Invertebrate Paleontology," by permission of McGraw-Hill Book Co., Inc.]. **19. Esmeraldina macer** (x2) [GSA, B 49]. The obliquely compressed holotype. **20–24.** Diagrams to show structures around anterior portion of cephalon [original: R. R. Shrock] (*b*, brim; *d*, doublure; *g*, glabella; *r*, rim). **25.** Diagram to show structural features on pygidial pleura [original: R. R. Shrock; suggested by C. E. Resser].



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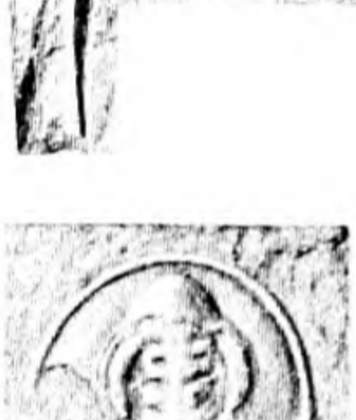

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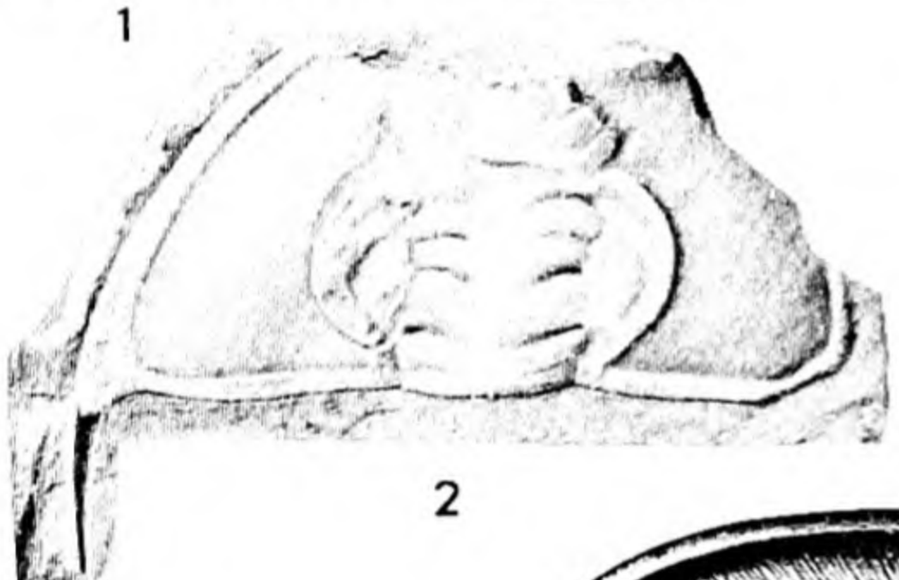

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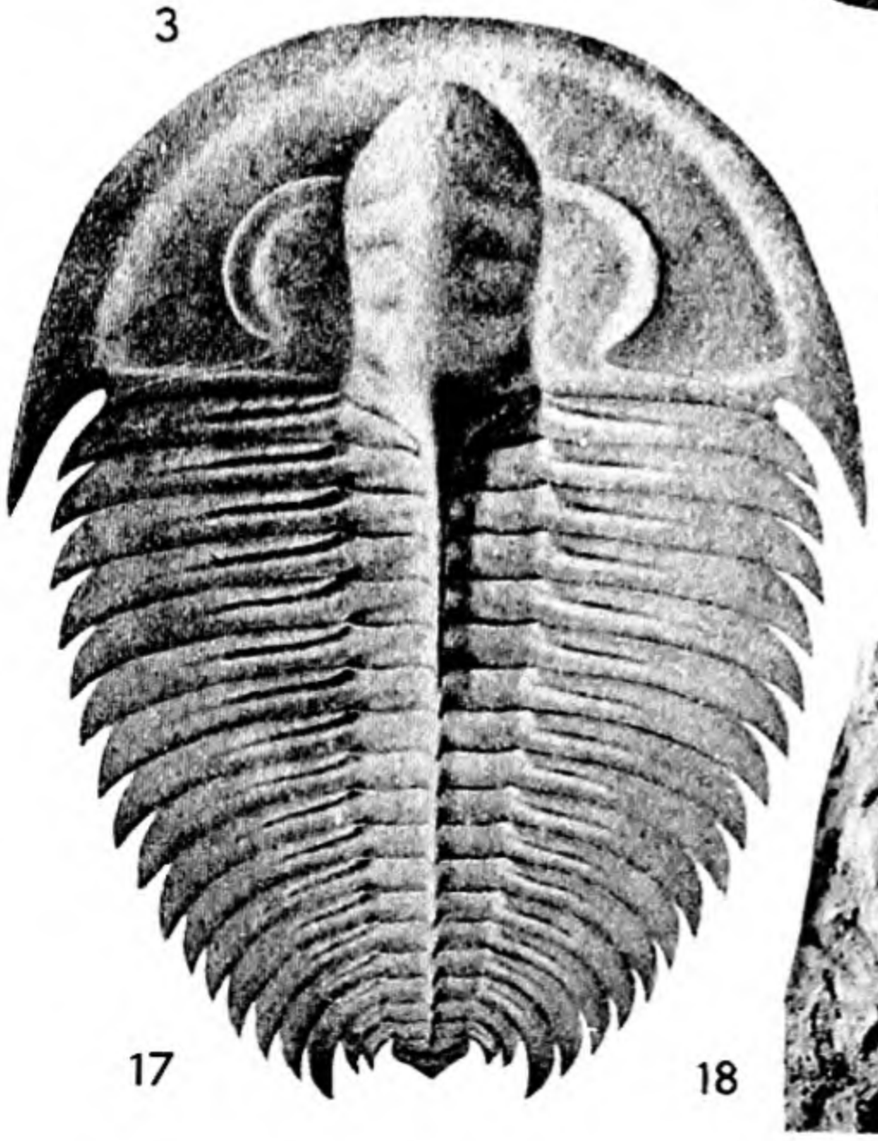

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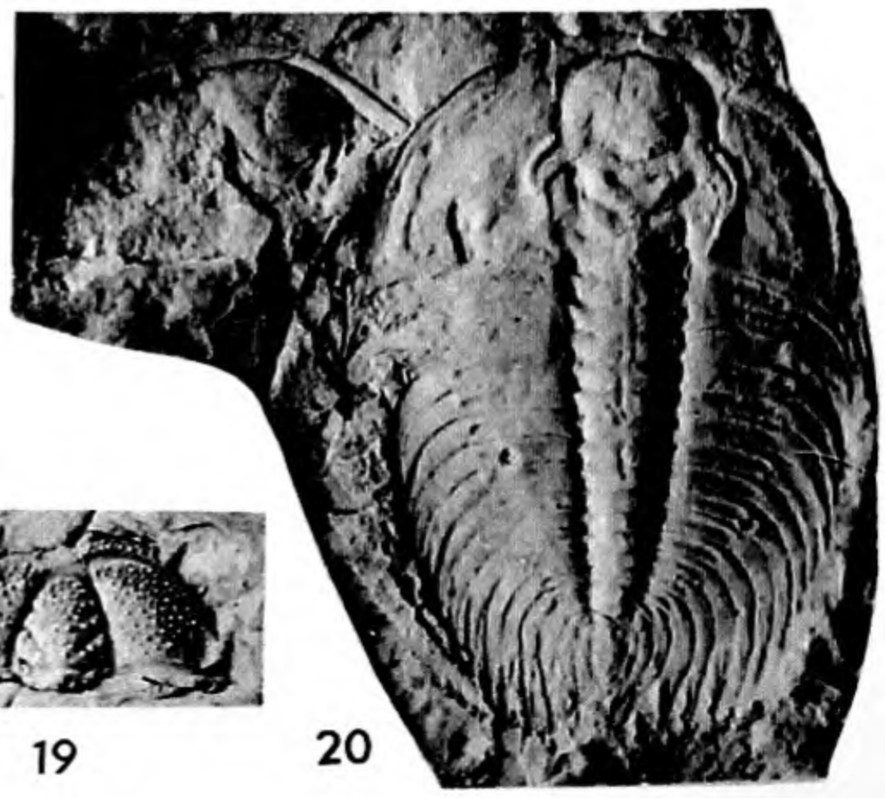

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The posterior part of the shell is the *abdomen* or *pygidium*, consisting of a single piece divisible into a central axis or axial lobe and two lateral or pleural lobes. The dorsal furrows of the thorax may continue on the pygidium, making the division line between thorax and pygidium obscure.

Probably all trilobites had jointed appendages — antennae, mouth parts, legs, and gill fringes — roughly comparable in a general way to those of the modern lower crustaceans, but these structures are rarely preserved.

Trilobites appear first in the Lower Cambrian and last in the Permian. They are worldwide in their distribution and of great value as index fossils, particularly in lower Paleozoic rocks.

LOWER AND MIDDLE CAMBRIAN TRILOBITA

[Genera arranged alphabetically]

AGRAULOS Hawle and Corda 1846

(**Arion ceticephalus* Barrande). Fixed cheeks and preglabellar area gently convex, with front of latter thickened; eyes small; 16 thoracic segments; pygidium with three annulations on axis. **L.** and **M. Camb.** (eastern N. America; Europe).

A. quadrangularis (Whitfield) (**255**—13, 14). Neck ring with cylindrical spine; cranidium subquadrangular. **M. Camb.:** Mass. (Braintree)

ALBERTELLA Walcott 1908

(**A. helena*). Differs from *Zacanthoides* in the reduced brim, smaller eyes, and greater width of fixed cheeks; anterior facial sutures also less divergent; seven thoracic segments with the pleura ending in spines, and the third segment with macropleural development; pygidium with a pair of long marginal spines. **M. Camb.** (Cordilleran region).

***A. helena** Walcott (**258**—1–3). **M. Camb.:** Mont. (Gordon); B. C.

ALOKISTOCARE Lorenz 1906

(**Conocephalites subcoronatus* Hall and Whitfield). Test narrowing from rather large cephalon to small pygidium; dorsal furrows strong; glabellar furrows short, in two or three pairs; palpebral lobes and eyes of medium size; thorax with 17 to 19 segments; pygidium small, with axial lobe prominent and with about three rings. **M. Camb.** (N. America).

A. americanum (Walcott) (**255**—16). **Maryville:** Ala.

A. idahoense Resser (**255**—9). **Spence.** Wasatch Mts.

ANDRARINA Raymond 1937

(= LIOSTRACUS of American authors)

(**Liostracus aculeatus* Angelin). Brim concave, no genal spines on free cheeks, eyes of medium size and ocular ridge well developed; glabella well developed; pygidium small, not spined. **M. Camb.** (Atlantic Province).

A. tenera (**259**—12, 13; **276**—25). Ocular ridges thin and sharp; a separate, but similar, sharp ridge on each fixed cheek back of ocular ridge. **M. Camb.:** Newf. (Chamberlin's Brook); N. B. (Fossil Brook).

A ouangondiana (Hartt) (**276**—26). Similar to preceding, with which it occurs, but with ocular ridges of normal type and without ridges on fixed cheeks.

ANORIA Walcott 1924

(**Dolichometopus tontoensis*). Differs from *Glossopleura* in having smaller eyes, and in numerous other features discussed under that genus. **M. Camb.**

***A. tontoensis** (Walcott) (**258**—18). **M. Camb.:** Grand Canyon, Ariz. (Bright Angel).

ANTAGMUS Resser 1936

(**Ptychoparia teucer* Walcott, not *Conocephalites teucer* Billings). Glabella tapering, two-thirds cranidial length, with two to three pairs of short furrows; thickened rim occupies most of brim; anterior furrow curved backward to meet dorsal furrow. **L. Camb.** (N. America).

***A. typicalis** Resser (= **Ptychoparia teucer** Walcott) (**253**—6). **Parker:** Vt.

ARMONIA Walcott 1924

(**Asaphiscus* (*Blainia*) *elongatus* Walcott [*pars*]). Differs from *Elrathia* in having a narrow intramarginal furrow in front of preglabellar area. **M. Camb.** (N. America).

***A. elongata** (Walcott) (**255**—21). **Maryville:** Ala.

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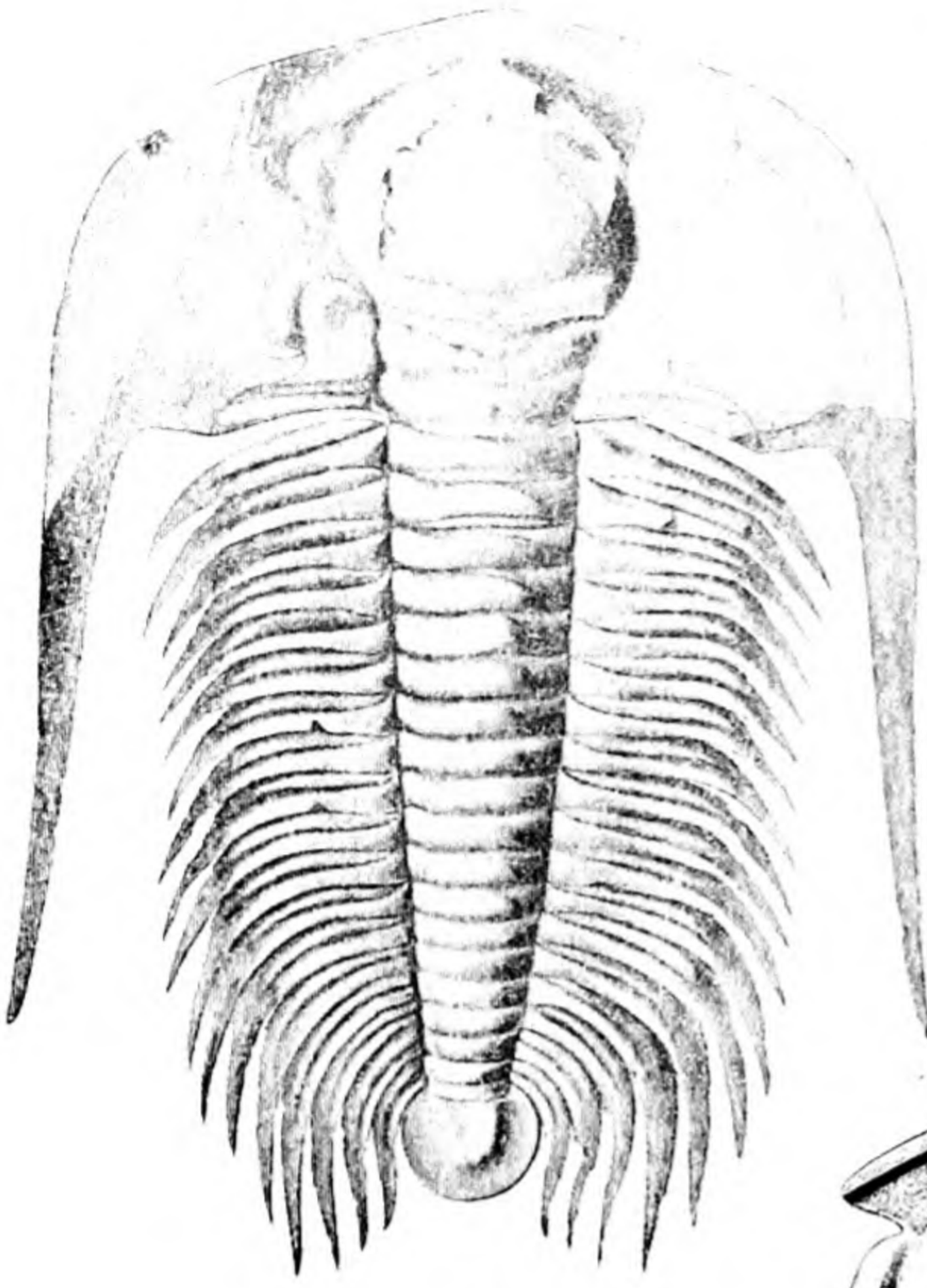
ern California: *San Diego Soc N H*, Tr 8: 47–52, 1935. **Whitcomb, L.,** New information on *Homalonotus trentonensis: GSA*, B 41: 341–350, 1930. **Whitfield, R. P.,** Paleontology of Wisconsin: *Wis G S* 4: 161–363, il, 1882; 1: 362–375, 1883. **Whittington, H. B.,** The Trinucleidae — with special reference to North American genera and species: *JP* 15: 21–41, il, 1941; Silicified Trenton trilobites: *JP* 15: 492–522, il, 1941.

PLATE 253

[Figures are x1 unless otherwise indicated; photographs furnished by Resser are indicated by CER.]

1–4. Olenellus spp. 1. O. vermontanus (reduced) [GSA, B 49]. **2, 3. O. gilberti** [SMC 53 (6)]. Two cephalons somewhat crushed and flattened. **4. O. thompsoni** (x0.7) [GSA, B 49]. **5. Conocoryphe terranovica** (x1.5) [CER]. **6. Antagmus typicalis** (x3) [CER]. Nearly complete cranidium. **7, 8. Kochiella mansfieldi** (x1.5) [SMC 98 (24); CER]. Holotype cranidium; partly preserved pygidium. **9. Protolenus (Bergeronia) elegans** (x2) [CER]. Nearly complete cranidium. **10–12. Bailiella baileyi** [USGS, B 10]. Enlarged cephalon; pygidium; left portion of cephalon showing genal spine. **13. Ctenocephalus howelli** [CER]. **14, 15. Kochina americana** [CER]. Two cephalons showing variation in specimens. **16. Bailiaspis prominens** (x1.5) [CER]. **17. Callavia bröggeri** (x0.5) [SMC 53 (6)]. Restoration. **18. Strenuella strenua** (x3) [CER]. **19. Bailiaspis venusta** [CER]. **20. Wanneria walcottana** (x0.7) [GSA, B 49; CER]. Holotype.



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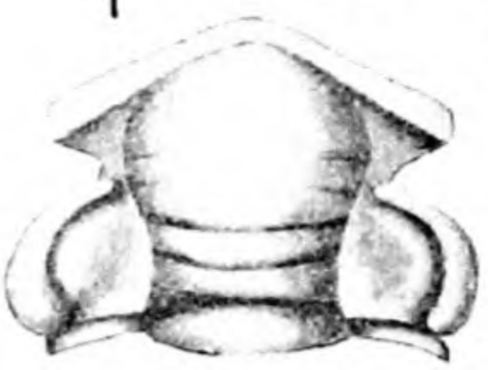

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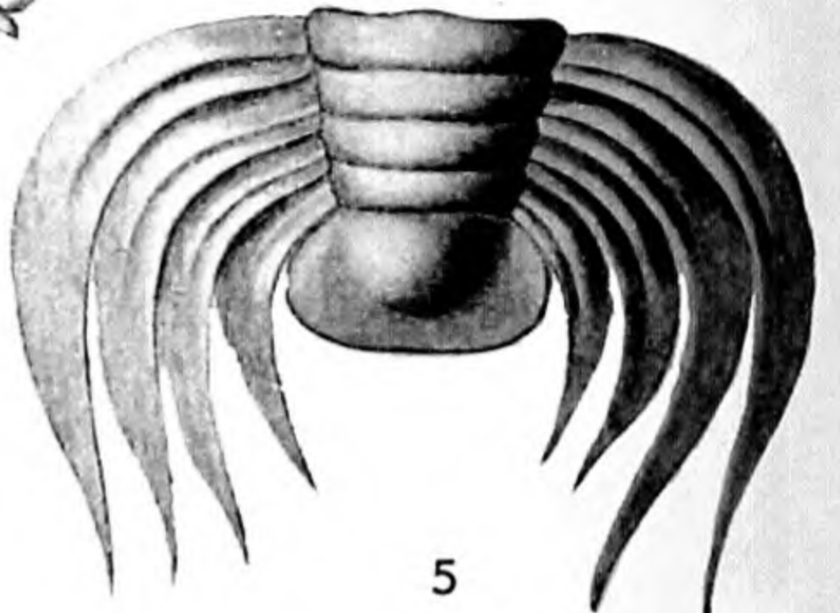

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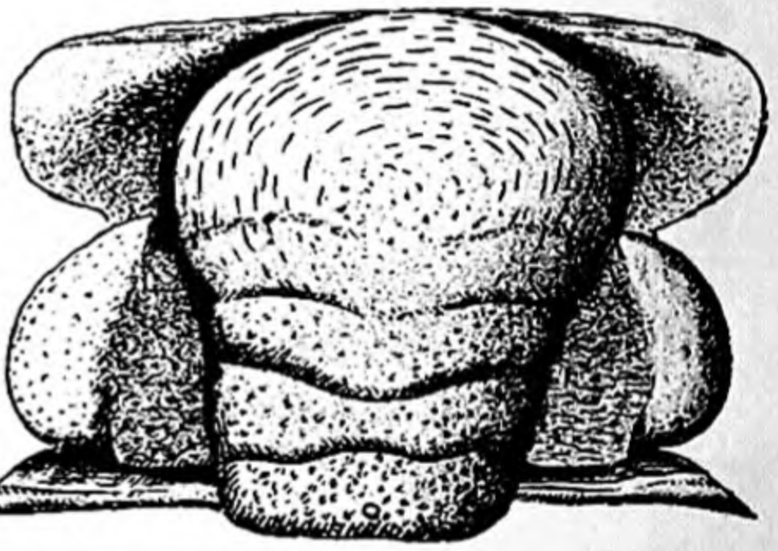

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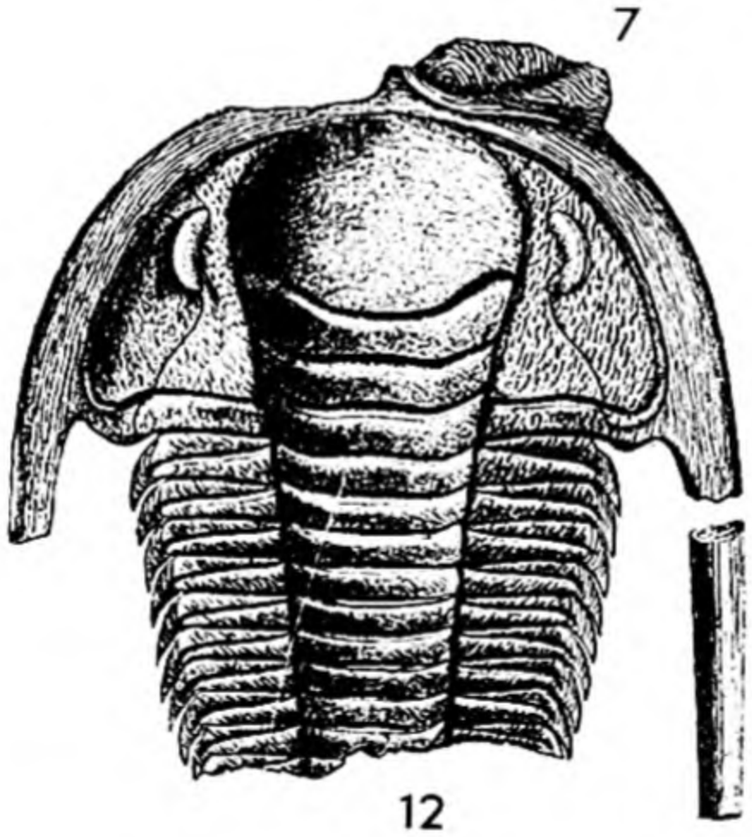

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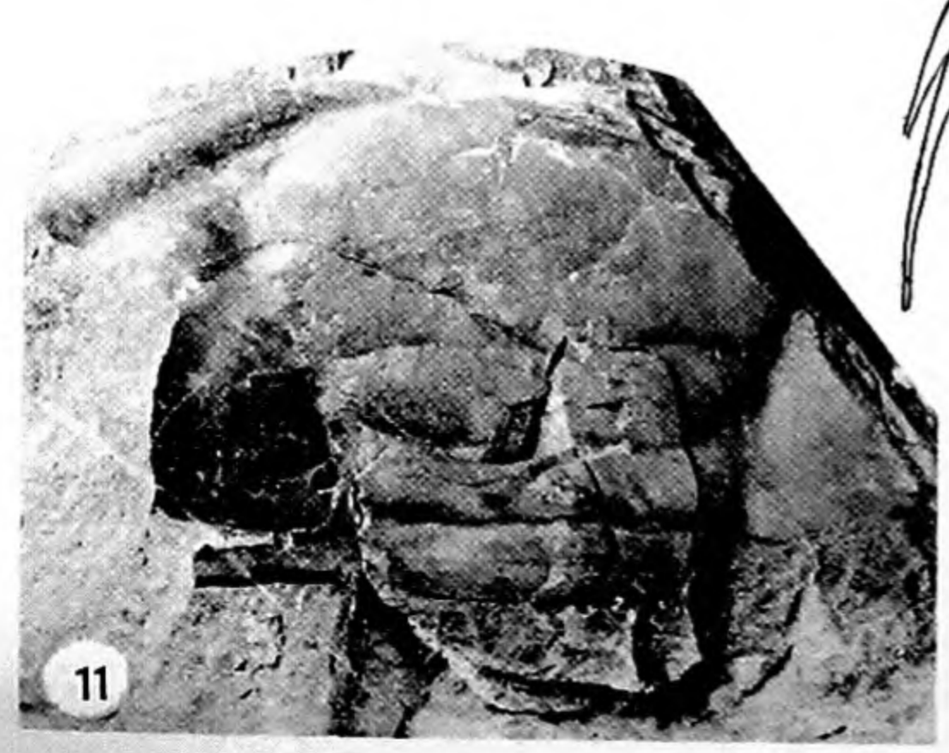

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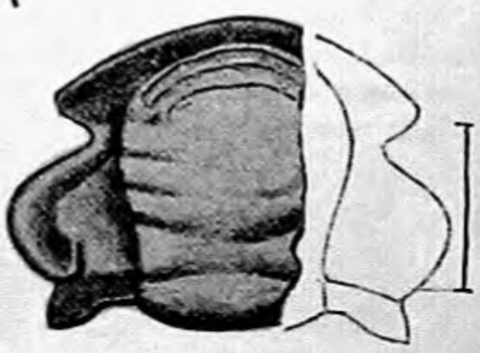

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ASAPHISCUS Meek 1873

(**A. wheeleri*). Differs from *Bathyuriscus* in that the conical glabella has in front of it a broad preglabellar area and rim; eyes more anterior and farther from glabella; genal spines lacking. **M. Camb.** (Cordilleran region).

***A. wheeleri** Meek (**258**—9). Cephalon depressed; segmentation of pygidium indistinct. **M. Camb.** (Wheeler): Utah, Nev.

BAILIASPIS Resser 1936

(**Conocephalites elegans* Dawson). Differs from *Bailiella* in having a longer glabella. **M. Camb.** (Atlantic Province).

B. venusta Resser (**253**—19). **Manuels:** Newf.

B. prominens Resser (**253**—16). **Manuels:** Newf.

BAILIELLA Matthew 1885

(**Conocephalites baileyi* Dawson). Cephalon semicircular, finely granulose, with genal spines; glabella tapering, rounded at front, not extending to front margin, with three faint, backwardly directed furrows and a well developed neck furrow; fixed cheeks very large, free cheeks narrow; pygidium small, with entire margin; axial lobe with three segments. **M. Camb.** (Atlantic Province).

***B. baileyi** (Dawson) (**253**—10–12; **276**—21). **Fossil Brook:** N. B.

B. venulosa (Salter) (**276**—20). **Kelligrew Brook:** Newf.

BATHYURISCUS Meek 1873

(**Bathyurus? haydeni*). Glabella contracted medially, more expanded anteriorly, marked by three to four pairs of glabellar furrows; eyes elongate; thorax with seven to nine segments, strong axial lobe, and broadly grooved pleura; pygidium semicircular, and with annulated axial lobe. **M. Camb.** (N. America).

B. formosus Deiss (**258**—11). Differs from genotype in having much longer eye lobes, posterior glabellar furrows not continued across glabella, and strong but short spines on axial lobe of glabella. **Meagher:** Mont.

B. rotundatus (Rominger) (**258**—12). **Stephen:** B. C.

BICASPIS Resser 1937

(**B. typica*). Cranidium tumid, glabella wide and highly arched; brim simple, concave; hypostoma tumid, with deep transverse furrow back of middle; pygidium short, wide, with anterior angles prolonged into spines. **L. Camb.** (eastern N. America).

***B. typica** Resser (**259**—17, 18). **L. Camb.:** Que.

BLAINIA Walcott 1916

(**Asaphiscus (Blainia) gregarius*). Cranidium elongate; glabella conical, strongly convex, with three pairs of short furrows; posterolateral limbs broad. **M. Camb.** (eastern U. S. A.).

***B. gregaria** (Walcott) (**259**—19). **Maryville:** Ala.

BOLASPIS Resser 1935

(**Alokistocare? labrosum* Walcott). Cranidium characterized by conical glabella; fixed cheeks wide and tumid; eyes small and sometimes stalked; large, rounded or triangular elevation in preglabellar area; rim flat and erect; neck ring heavy, in some species extended into spine. **M. Camb.** (N. America).

***B. labrosum** (Walcott) (**255**—25, 26). **Wolsey:** Mont.

BONNIA Walcott 1916

(**Bathyurus parvulus* Billings). Small; characterized by a long, essentially quadrate glabella, in some species expanded and occupying entire length of cranidium; brim narrow, concave; fixed cheek equals glabellar width; eye large; free cheek generally with short genal spine; pygidium about same size as cranidium; axis usually arched above pleural lobes; one to three marginal spines at anterior angles; many species. **L. Camb.** (N. America).

***B. parvula** (Billings) (**256**—5). **Forteau:** Labrador.

B. senecta (Billings) (**256**—11, 12). **Forteau:** Newf.; Labrador.

B. fieldensis Walcott (**256**—13, 14). **Mt. Whyte:** B. C.

BONNIELLA Resser 1937

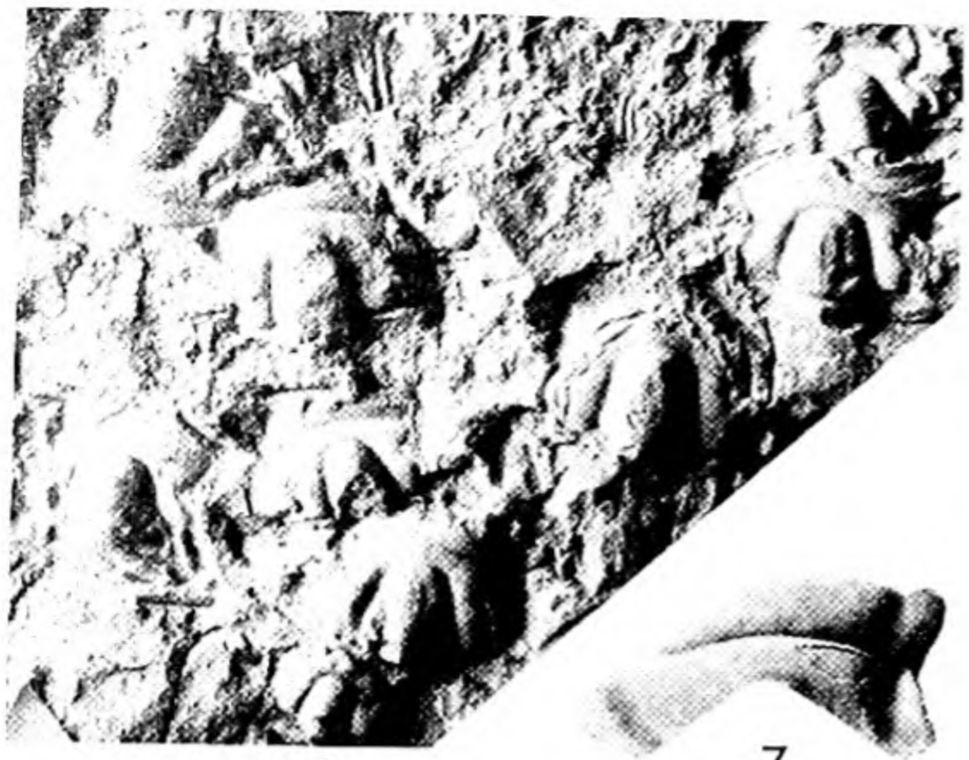
(**Olenoides (Dorypyge) desiderata* Walcott). Cranidium quadrate; glabella highly arched, with steep anterior slope and a tendency to expand forward; cranidium generally granulose; pygidium has marginal spines at anterior angles, but has less complete pleural fusion than present in most species of *Bonnia*. **L. Camb.** (N. America).

***B. desiderata** (Walcott) (**256**—6, 7). **L. Camb.:** Vt.

PLATE 254

[Figures are x1 unless otherwise indicated.]

1–15. Paradoxides spp. 1, 2. P. eteminicus [USGS, B 10; after Matthew]. Small pygidium and medium-sized cranidium. **3–7. P. harlani** [USGS, B 10]. 3: Large hypostoma attached to epistoma (x0.7). 4: Broad pygidium. 5: Four posterior thoracic segments and pygidium. 6: A large specimen, partly restored (x0.5). 7: Medium-sized cranidium. **8. P. ebenacus** [R Soc Can (1) 3 (4)]. Slightly distorted cranidium. **9, 10. P. hicksi** [GSL, QJ 25]. Incomplete cranidium; pygidium with last two thoracic segments. **11. P. matthewi** [WFIS, B 10 (4); photograph furnished by B. F. Howell]. Incomplete cephalon. **12, 13. P. davidis** [GSL, QJ 20]. Half grown specimen (x0.7); typical pygidium with great sabre-shaped lateral spines, and the last four thoracic segments restored. **14, 15. P. lamellatus** [USGS, B 10]. The two type specimens, partly restored. **16. Centropleura vermontensis** [photograph furnished by B. F. Howell]. An incomplete cephalon. **17. Peachella iddingsi** [SMC 53 (6)]. Complete cephalon, the type specimen, restored. **18. Paedeumias transitans** [photograph furnished by C. E. Resser].



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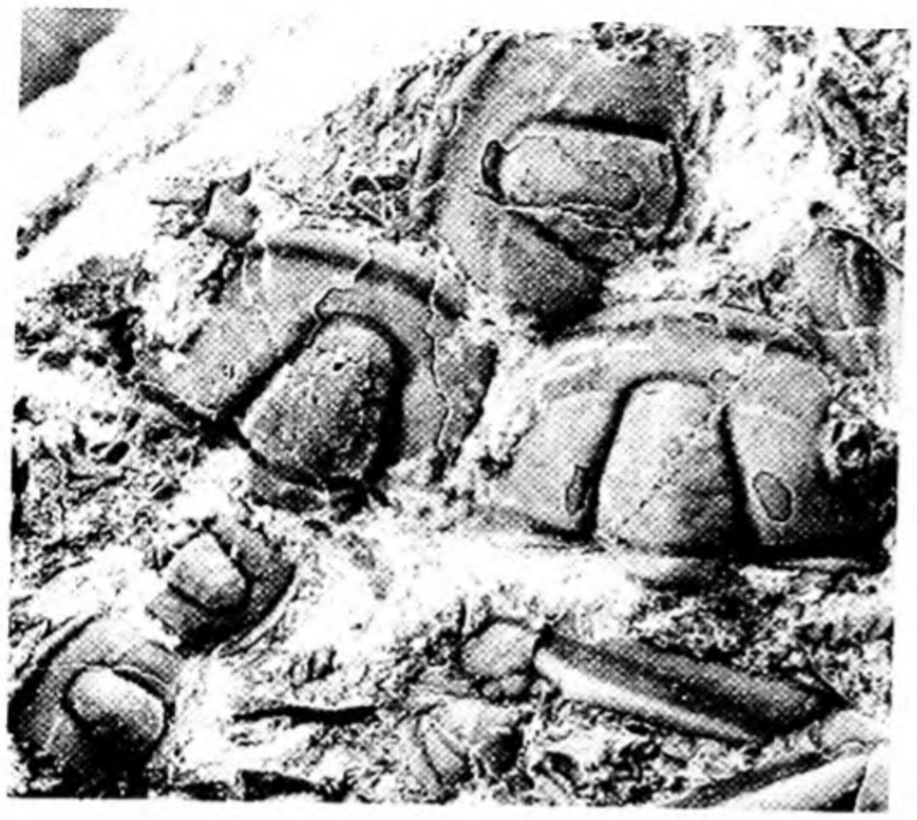

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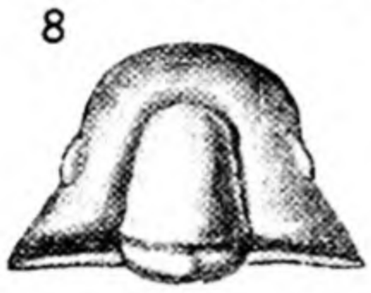

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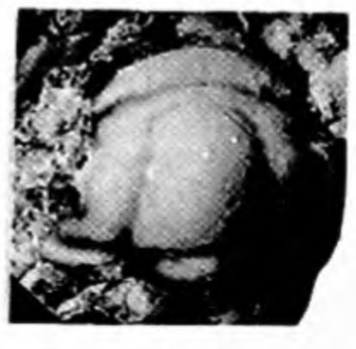

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B. tumida Resser (**256**—19). **Shady:** Va.
B. virginica Resser (**256**—17). **Shady:** Va.

CALLAVIA Matthew 1897

(**Olenellus* (*Holmia*) *bröggeri* Walcott). Glabella tapering forward, not reaching rim; long occipital spine, and short spines on all thoracic segments; 18 thoracic segments, last 2 reduced; pygidium small. **L. Camb.** (Atlantic Province).

***C. bröggeri** (Walcott) (**253**—17). **Brigus:** Newf.

CENTROPLEURA Angelin 1854

(**Paradoxides lovéni*). Resembles *Paradoxides* but facial sutures diverge more in front of eye. glabella bears a backwardly directed indentation on each side near its front; and pygidium has two pairs of spines; eye lobes long. **M. Camb.** (Atlantic Province).

C. vermontensis Howell (**254**—16). **St. Albans:** Vt.

CHANCIA Walcott 1924

(**C. ebdome*). Differs from *Elrathia* in its wider fixed cheeks and wider rim, but more particularly in its small pygidium. **M. Camb.** (N. America).

***C. ebdome** Walcott (**255**—2, 3). **Spence:** Wasatch Mts.

CLAPPASPIS Deiss 1939

(**C. typica*). Like *Elrathiella* but differs in having wider fixed cheeks, smaller and more elevated eye lobes, a more conical glabella, deeper glabellar furrows, and distinct tuberculate surface ornamentation. **M. Camb.** (Cordilleran region).

***C. typica** Deiss (**255**—12). **Pentagon:** Mont.

CLAVASPIDELLA Poulsen 1927

(**C. sinupyga*). Glabella one and a fourth times as long as broad, greatly expanded in front; glabellar furrows strongly impressed; third pair shorter than preceding, forming right angles with axis; posterior furrows oblique, converging toward neck ring; occipital furrow deep, broad; dorsal furrows unusually wide and deep; posterolateral limbs narrow. **M. Camb.** (N. America).

C. anax Walcott (**259**—22). **Spence:** Wasatch Mts.

C howelli (Walcott) (**259**—3). **Chisholm:** Nev.

CONOCORYPHE Hawle and Corda 1847

(**Trilobites sulzeri* Schlotheim). Cephalon semicircular, coarsely granulose; genal angles produced into spines; glabella tapering, rounded at front, not extending to front margin, with three backwardly directed furrows and a well developed neck furrow; fixed cheeks large, free cheeks narrow; pygidium small, with entire margin; axial lobe with about six segments. **M. Camb.** (Atlantic Province).

C. terranovica Resser (**253**—5). **Manuels:** Newf.

CTENOCEPHALUS Hawle and Corda 1847

(**Conocephalus coronatus* Barrande). Cephalon semicircular, genal angles produced into spines; glabella lobed, tapering, with three backwardly directed furrows and a well developed neck furrow; a boss in front of the glabella; fixed cheeks high and large, their anterior slopes almost perpendicular; free cheeks narrow; pygidium small with entire margin and axial lobe with two segments. **M. Camb.** (Atlantic Province).

C. howelli Resser (**253**—13). **Manuels:** Newf.

DAWSONIA Hartt in Dawson 1868

(**Microdiscus dawsoni*). Eodiscid with long glabella and pygidium which has segmented axial lobe and pleural furrows. **L.** and **M. Camb.** (N. America).

D. lobatus (Hall) (**252**—2, 3). **L. Camb.:** N. Y. (Schodack).

***D. dawsoni** (Hartt) (**252**—10–12). **M. Camb.:** Newf. (Chamberlin's Brook); N. B. (Fossil Brook).

DEISSELLA Howell and Duncan 1939

(**Ptychoparia? convexa* Howell). Cranidium wide at rear, tapering rapidly anteriorly; glabella narrow and conical, truncate at front, strongly convex; rim strongly upturned at front, bent steeply downward at sides; free cheeks wide, convex, with eyes level with top of glabella. **M. Camb.** (Atlantic Province).

***D. convexa** (Howell) (**255**—15). **St. Albans:** Vt.

DOLICHOMETOPSIS Poulsen 1927

(**D. resseri*). Differs from *Ptarmigania* in longer glabella, and presence of four marginal spines on pygidium. **M. Camb.** (Greenland; Cordilleran region).

D. gravis Resser (**258**—15). **Langston:** Wasatch Mts.

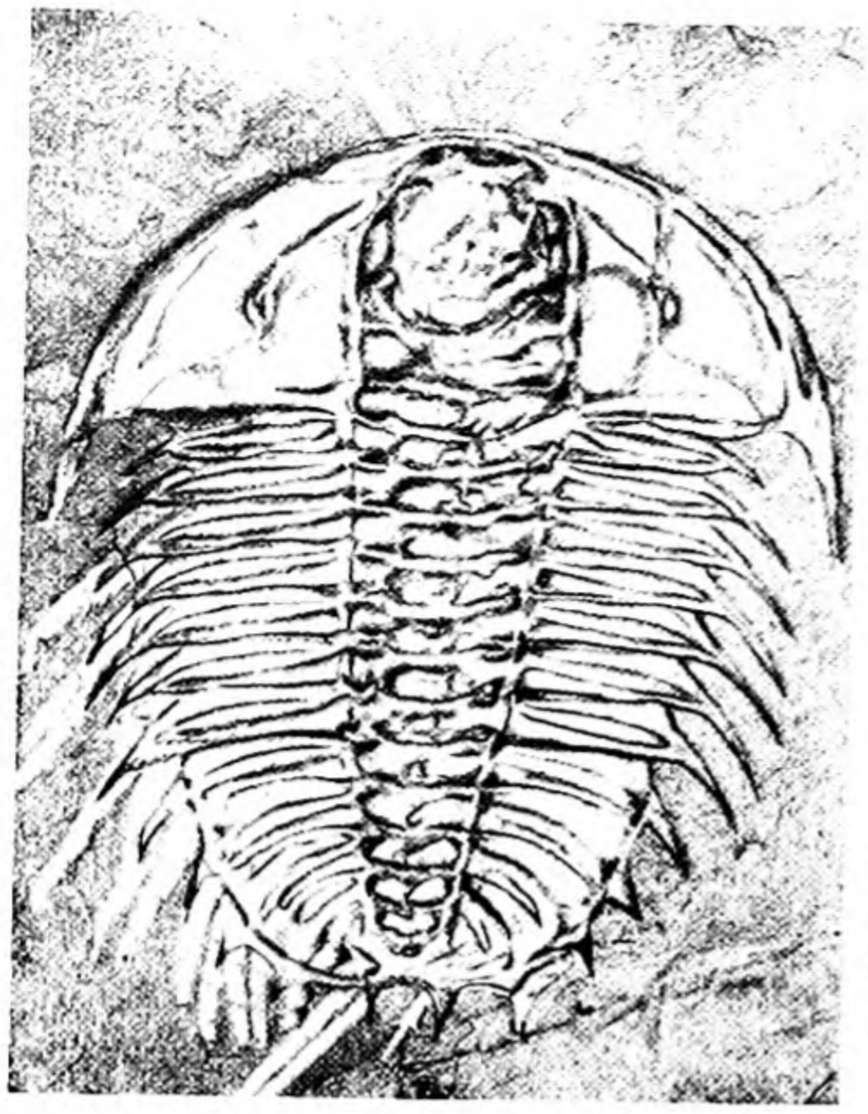
EHMANIA Resser 1935

(**E. weedi*). Glabella tapered and rounded, well defined, with faint glabellar furrows; brim somewhat

PLATE 255

[Figures are x1 unless otherwise indicated; photographs for all except 12–15, 17, and 25 furnished by C. E. Resser.]

1. Elrathiella buttsi. A slab with numerous cranidia (x1.5). **2, 3. Chancia ebdome** [SMC 97 (12)]. Cranidium with left free cheek displaced; a well preserved specimen. **4. Elrathina cordillerae. 5, 6. Elrathia kingi.** Nearly complete specimen; considerably fractured specimen enlarged (x1.5). **7, 8. Pachyaspis typicalis** (x3) [SMC 98 (24)]. Side view of holotype cranidium; slab with cranidia. **9. Alokistocare idahoense** [SMC 97 (12)]. Holotype. **10, 11. Proliostracus goodwini** [GSA, SP 15]. Cranidia (x1.5). **12. Clappaspis typica** [GSA, SP 18]. Holotype (x3). **13, 14. Agraulos quadrangularis.** Cranidium [photograph furnished by B. F. Howell]; Walcott's early figure [USGS, B 10]. **15. Deisselia convexa** [WIFS, B 14 (1)]. Holotype cranidium (x2). **16. Alokistocare americanum.** Lectotype. **17. Elrathiella nitida** [GSA, SP 18]. Holotype (x2). **18, 19. Ehmania gallatinensis.** Cranidia. **20. Eteraspis laeviceps. 21. Armonia elongata. 22. Solenopleu- 'la buttsi.** Slab with numerous cranidia (x2). **23, 24. Eteraspis glabra.** Cranidium and exfoliated pygidium. **25, 26. Bolaspis labrosum** (x3). Walcott's retouched figure [SMC 64 (3)]; photograph of same specimen.



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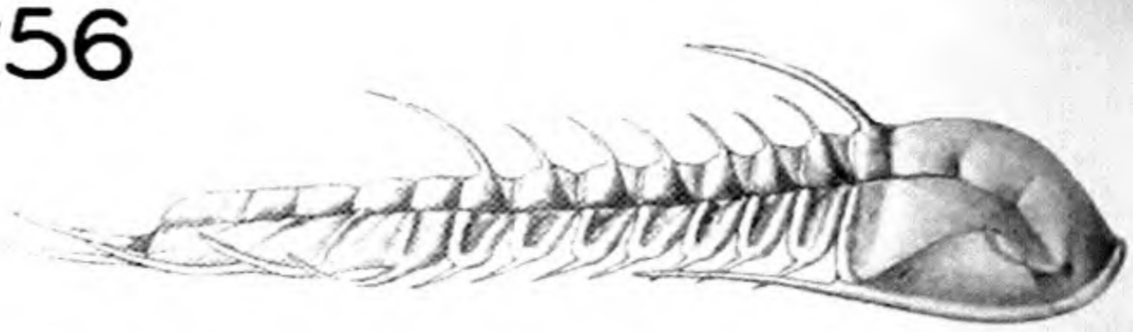

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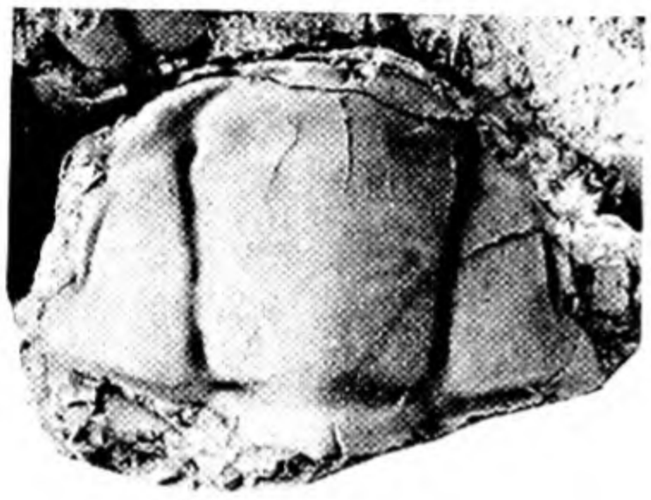

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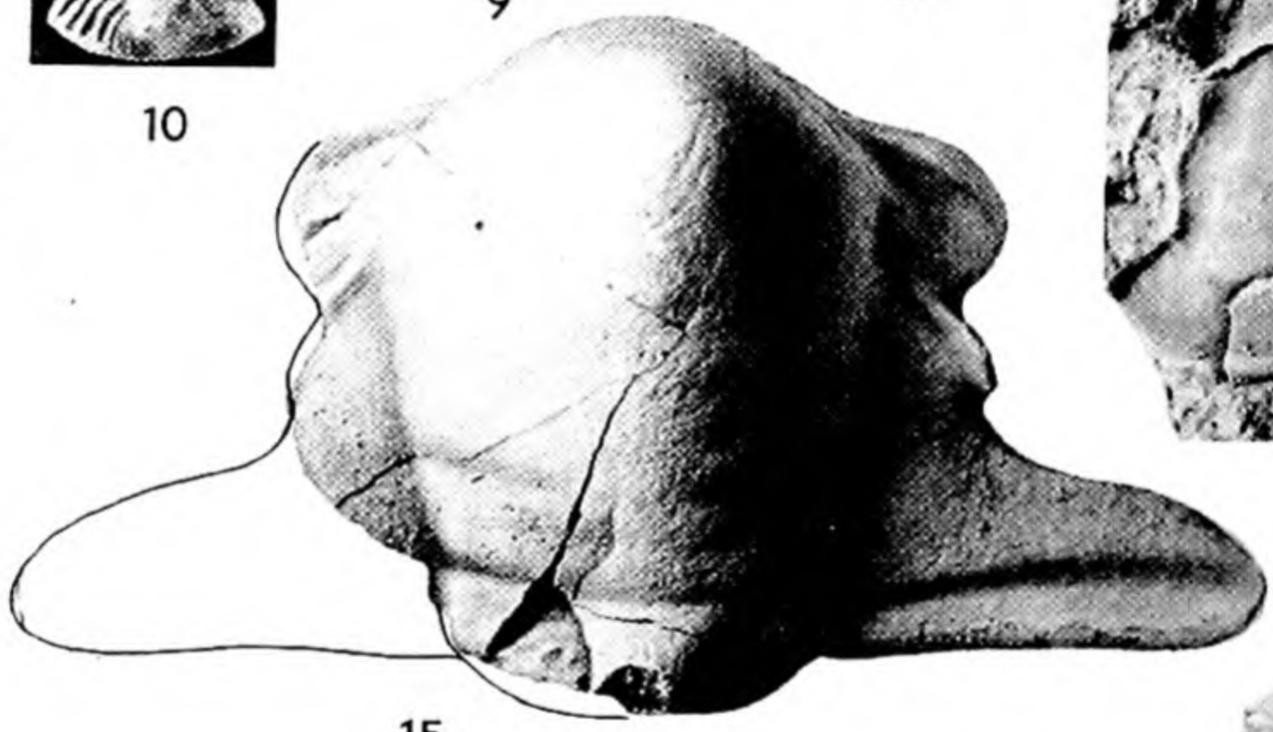

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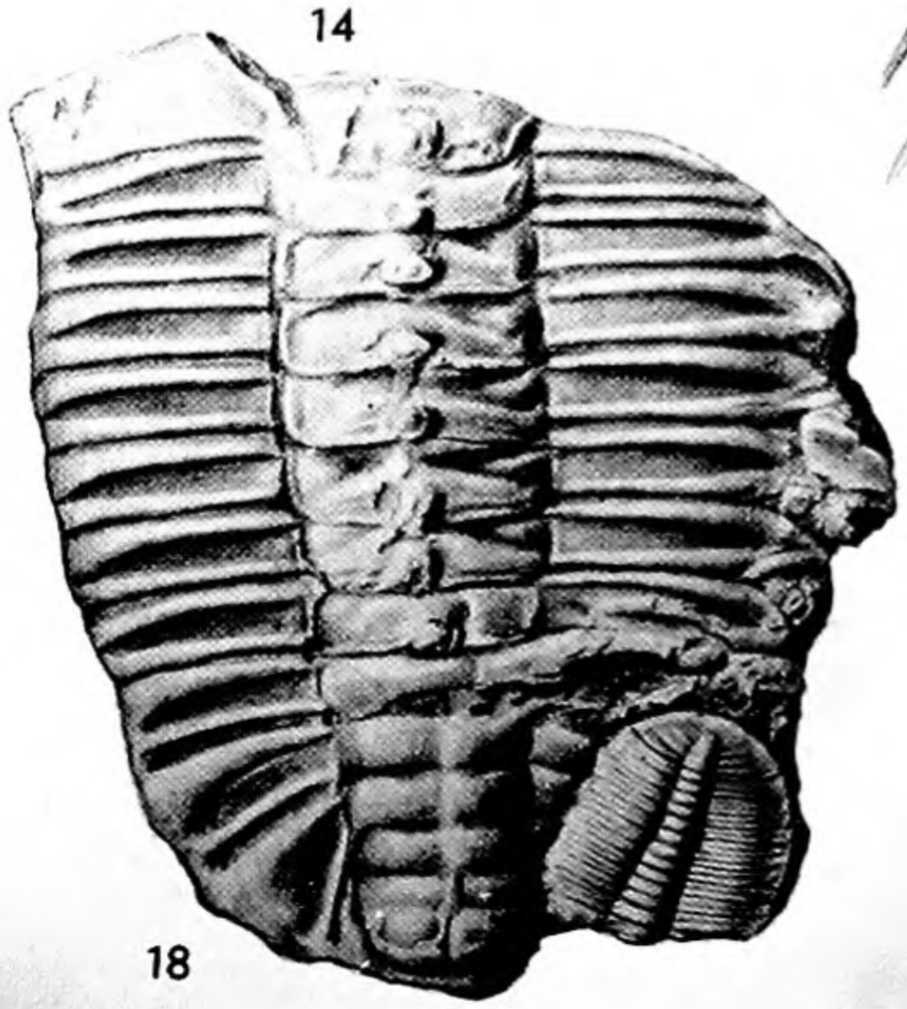

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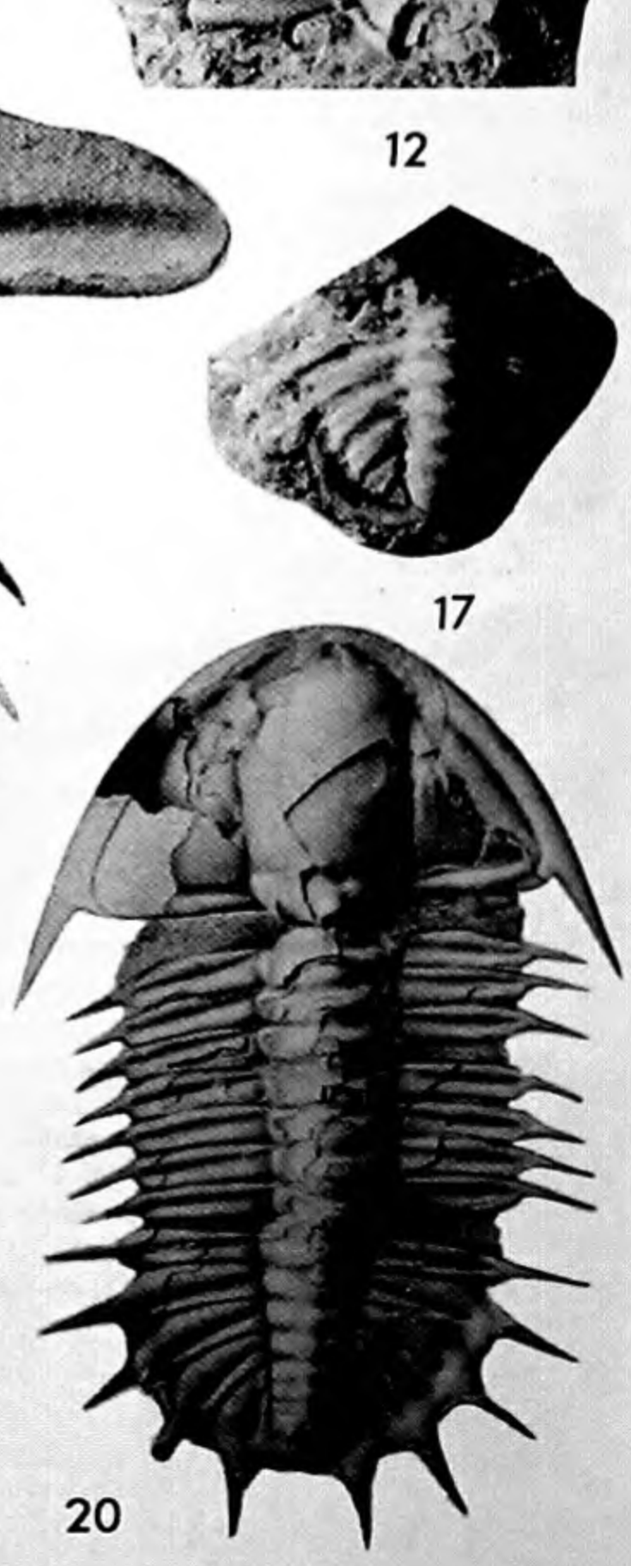

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convex; rim slightly upturned; pygidium marked by both pleural grooves and furrows extending to border. **M. Camb.** (N. America).

E. gallatinensis (Meek) (**255**—18, 19). **Meagher:** Mont.

ELRATHIA Walcott 1924

(**Conocoryphe* (*Conocephalites*) *kingi* Meek). Characterized by wide brim, wide fixed cheeks and a large, flat furrowed pygidium. **M. Camb.** (N. America).

***E. kingi** (Meek) (**255**—5, 6). Glabella short, convex when not flattened in shale; circumglabellar furrow deep; 13 thoracic segments. **Wheeler:** Utah.

ELRATHIELLA Poulsen 1927

(**E. obscura*). Differs from *Elrathia* in its much narrower cranidium, wider rim, narrower brim, and long, narrow glabella. **M. Camb.** (N. America).

E. buttsi Resser (**255**—1). **M. Camb.:** S. Appalachians.

E. nitida Deiss (**255**—17). **Pentagon:** Mont.

ELRATHINA Resser 1937

(**Conocephalites cordillerae* Rominger). Similar to *Elrathia*, but possessing a smaller pygidium and a narrower preglabellar area; thorax long, tapering to small pygidium. **M. Camb.** (Cordilleran region).

***E. cordillerae** (Rominger) (**255**—4). **Stephen:** B. C.

EODISCUS Matthew 1896

(**E. schucherti*). Eodiscid with short glabella, long or blunt neck spine, and pygidium with segmented axial lobes and no pleural furrows. **L.** and **M. Camb.** (N. America).

E. speciosus (Ford) (**252**—4–6). **L. Camb.:** N. Y. (Schodack).

E. punctatus (Salter) (**252**—1). **M. Camb.:** Newf. (Manuels).

ESMERALDINA Resser and Howell 1938

(**Holmia rowei* Walcott). Olenellids with wide glabella; eyes of moderate size; genal spines long; thorax considerably narrower than cephalon, with 17 segments; occipital and small axial spines; small pygidium. **L. Camb.** (N. America).

E. macer (Walcott) (**252**—19). **Kinzers:** Pa.

ETERASPIS Resser 1935

(**Ptychoparia laeviceps* Walcott). Glabella poorly defined, without furrows; neck rim thickened; dorsal furrows faint; brim one-third glabellar length; rim flat, wide; eyes moderately bowed, in about middle of cranidium **M. Camb.** (N. America).

***E. laeviceps** (Walcott) (**255**—20). **Eldorado:** Nev.

E. glabra (Walcott) (**255**—23, 24). **Maryville:** Tenn.

GLOSSOPLEURA Poulsen 1927

(**Dolichometopus boccar* Walcott). Differs from *Anoria* in having very long eye lobes, in lacking median tubercles on thoracic and pygidial segments, and in lacking macropleural development of fifth thoracic segment; many species. **M. Camb.** (N. America).

***G. boccar** (Walcott) (**258**—10). **Stephen:** B. C.

G. producta (Hall and Whitfield) (**258**—4, 5). **Ophir:** Utah.

GLYPHASPIS Poulsen 1927

(**Asaphiscus? capella* Walcott). Differs from *Asaphiscus* in having a concave brim, genal spines, and a broad, strongly segmented pygidium; pleural furrows continued into the concave border. **M. Camb.**

***G. capella** (Walcott) (**259**—14–16). **Wolsey:** Mont.

HOLTERIA Walcott 1924

(**Ogygia? problematica*). Glabella long, expanded anteriorly, reaching front of cranidium, with no rim in front of it; fixed cheeks narrow, eyes small, posterolateral limbs wide; pygidium large, with small axial lobe and two pairs of large spines. **M. Camb.** (Cordilleran region).

***H. problematica** (Walcott) (**259**—20, 21). **Eldorado:** Nev.

KOCHASPIS Resser 1935

(**Crepicephalus liliana* Walcott). Glabella wide, tapering, clearly defined with two or more pairs of furrows; brim and rim subequal in width; fixed cheeks two-thirds glabellar width; eye lines heavy; eyes rather small; surface granulose. **L.** and **M. Camb.** (N. America).

***K. liliana** (Walcott) (**257**—16). **M. Camb.:** Nev. (Comet).

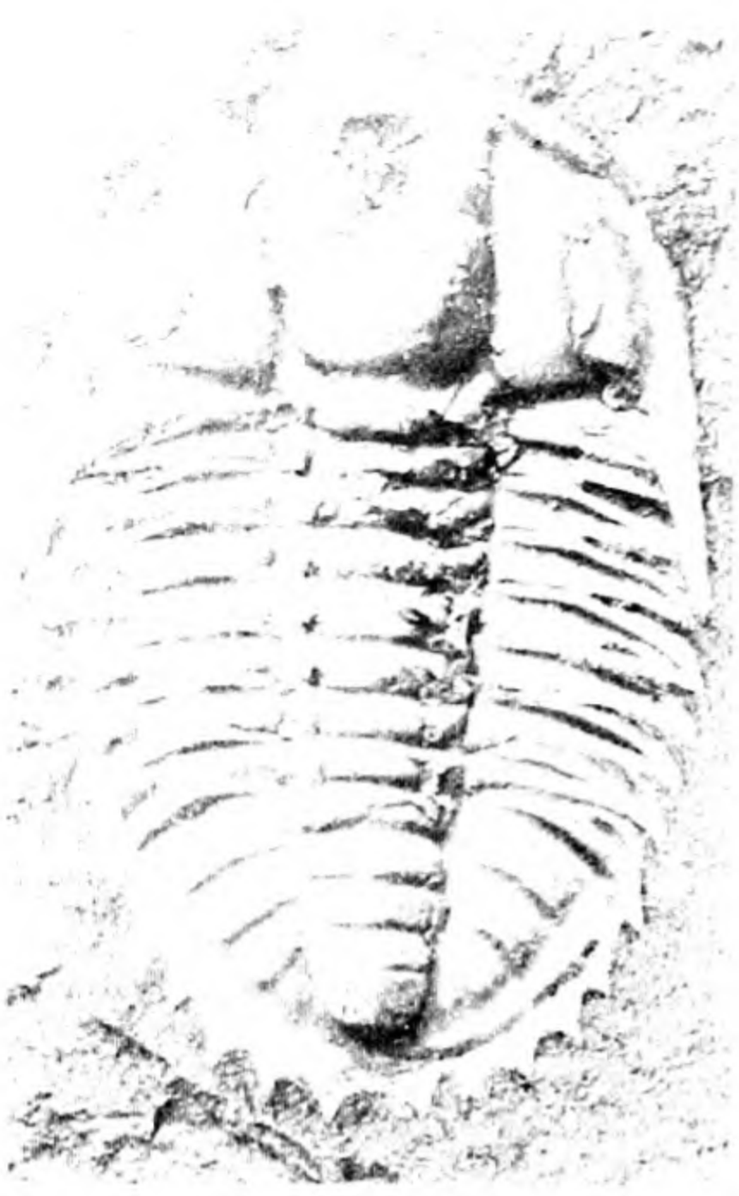
K. coosensis (Walcott) (**257**—12, 13). **M. Camb.:** Ala. (Maryville).

K. dispar Resser (**257**—17–19). **M. Camb.:** Wasatch Mts. (Langston).

PLATE 256

[Figures are x1 unless otherwise indicated; all figures except 1 and 8–10 were furnished by C. E. Resser.]

1. Olenoides serratus [SMC 67 (4)]. A nearly perfect dorsal shield, with some appendages extending out from beneath it. **2, 3. Pollella anteros** [SMC 97 (12)]. Top with hypostoma pressed through; dorsal view of holotype. **4. Olenoides curticei.** Side view of a restored specimen. **5. Bonnia parvula.** Holotype. **6, 7. Bonniella desiderata.** Cranidium and pygidium. **8–10. Thompsonaspis obscura** [GSA, SP 18]. Cranidia and pygidium. **11–14. Bonnia spp. 11, 12. B. senecta.** Holotype cranidium (x1, x2). **13, 14. B. fieldensis** (x3). Cranidium and pygidium. **15, 16. Olenoides inflatus** [SMC 53 (2)]. Restored cranidium and a nearly complete pygidium. **17. Bonniella virginica.** Pygidium. **18. Olenoides nevadensis** [USGS, B 30]. Type specimen. **19. Bonniella tumida.** Partly exfoliated cranidium. **20. Olenoides superbus** [SMC 53 (2)]. An almost complete dorsal shield.



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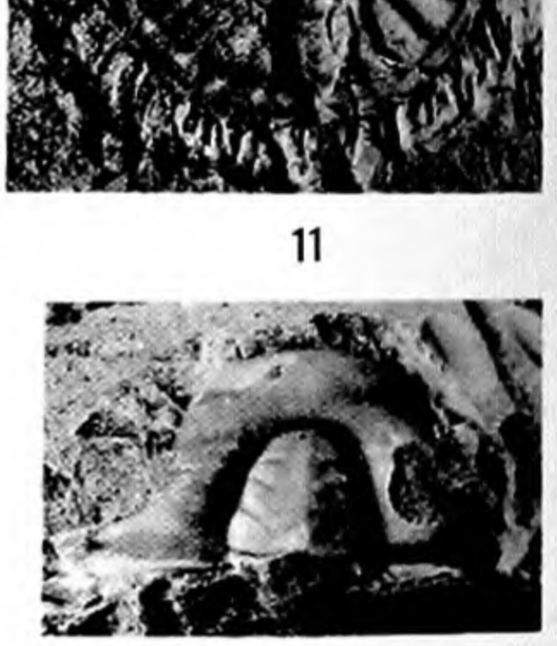

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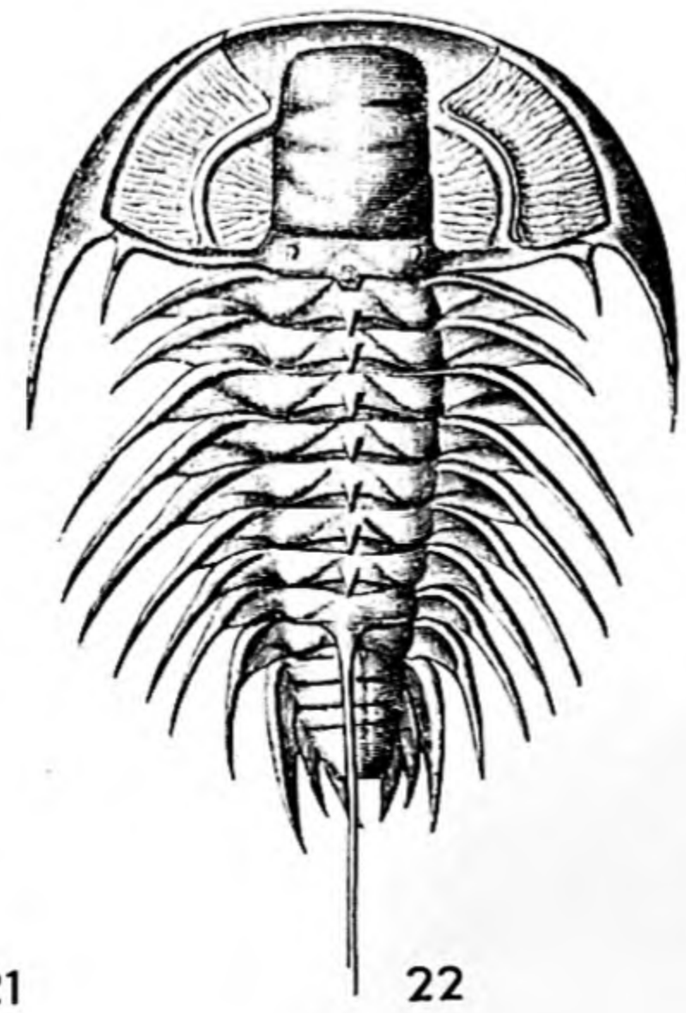

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KOCHIELLA Poulsen 1927

(**K. tuberculata*). Brim wide and flat with a narrow, faintly outlined rim; conspicuous feature of brim is impression of doublure on upper surface, simulating a wide rim bent back toward glabella at middle; eye lines wide; glabella with incomplete furrows; surface usually with scattered granules. **L.** and **M. Camb.** (N. America).

K. mansfieldi Resser (**253**—7, 8). **M. Camb.:** Wasatch Mts. (Langston).

KOCHINA Resser 1935

(**Olenopsis americanus* Walcott). Differs from *Kochiella* in having narrower rim and brim, anteriorly converging facial sutures, and more anterior eyes; thickening of rim toward center a prominent feature. **M. Camb.** (Cordilleran region).

***K. americana** (Walcott) (**253**—14, 15). **Gordon:** Mont.

KOOTENIA Walcott 1888

(**Bathyuriscus* (*Kootenia*) *dawsoni*). Glabella long, subparallel sided, broadly rounded; rim narrow, convex; fixed cheeks depressed; posterolateral limbs short, narrow; pygidium grooved, bearing numerous spines; many species. **L.** and **M. Camb.** (widespread in N. America; Siberia).

K. marcoui (Whitfield) (**257**—10, 11). Pygidium with flattened spines upon margin and nodes upon the four anterior rings of the axial lobe. **L. Camb.:** Que.; Vt.

K. currieri Resser (**257**—5). **L. Camb.:** Appalachians (Shady).

K. convoluta Resser (**257**—1–4). **M. Camb.:** Idaho (Langston).

***K. dawsoni** (Walcott) (**257**—6). **M. Camb.:** B. C. (Stephen).

MARJUMIA Walcott 1916

(**M. typa*). Glabella conical, with preglabellar area as wide as slightly convex rim; pygidium with large, long axial lobe and several spines. **M. Camb.** (Cordilleran region).

***M. typa** Walcott (**258**—17). **Marjum:** Utah.

OGYGOPSIS Walcott 1888

(**Ogygia klotzi* Rominger). Cephalon and pygidium large; eyes small and far apart, eye lines present. **M. Camb.** (Cordilleran region).

***O. klotzi** (Rominger) (**258**—16). **Stephen:** B. C.

OLENELLUS Hall 1862

(**Olenus thompsoni*). Front glabellar lobe somewhat expanded and may reach rim; large eye lobes not attached posteriorly; thorax variable in width, with variable number of segments, first 15 normal and remainder reduced; macropleural development of 3rd segment and large axial spine on 15th; segments posterior to 15th rudimentary; pygidium slightly lobed. **L. Camb.** (N. America).

***O. thompsoni** (Hall) (**253**—4). **Parker:** Vt.

O. vermontanus (Hall) (**253**—1). **Parker:** Vt.

O. gilberti White (**253**—2, 3). **Pioche:** Nev.

OLENOIDES Meek 1877

(= NEOLENUS Matthew 1899, *auct partim*)

(**Paradoxides? nevadensis*). Glabella long, somewhat expanded anteriorly, reaching rim; long neck spine; pygidium large with large axial lobe and numerous spines; differs from *Kootenia* in having pygidium less completely fused, so that both grooves and furrows remain, and in oblique direction of furrows on pleural segments. **M. Camb.** (N. America).

O. curticei Walcott (**256**—4). **Maryville:** Ala.

O. inflatus Walcott (**256**—15, 16). **Marjum:** Utah.

***O. nevadensis** (Meek) (**256**—18). **M. Camb.:** Utah; B. C.

O. serratus (Rominger) (**256**—1). **Stephen:** B. C.

O. superbus Walcott (**256**—20). **Marjum:** Utah.

ORRIA Walcott 1916

(**O. elegans*). Differs from *Ogygopsis* in having narrower cranidium with large eyes and wider posterolateral limbs, and longer pygidium with shorter axial lobe. **M. Camb.** (Cordilleran region).

***O. elegans** Walcott (**259**—1, 2). **Marjum:** Utah.

ORYCTOCARA Walcott 1908

(**O. geikiei*). Glabella long, reaching narrow rim, parallel sided, with deeply impressed furrows; eye very long; posterolateral limbs wide; pygidium fan-shaped with short axial lobe and many ribs. **M. Camb.** (Cordilleran region).

***O. geikiei** Walcott (**259**—8). **Spence:** Wasatch Mts.

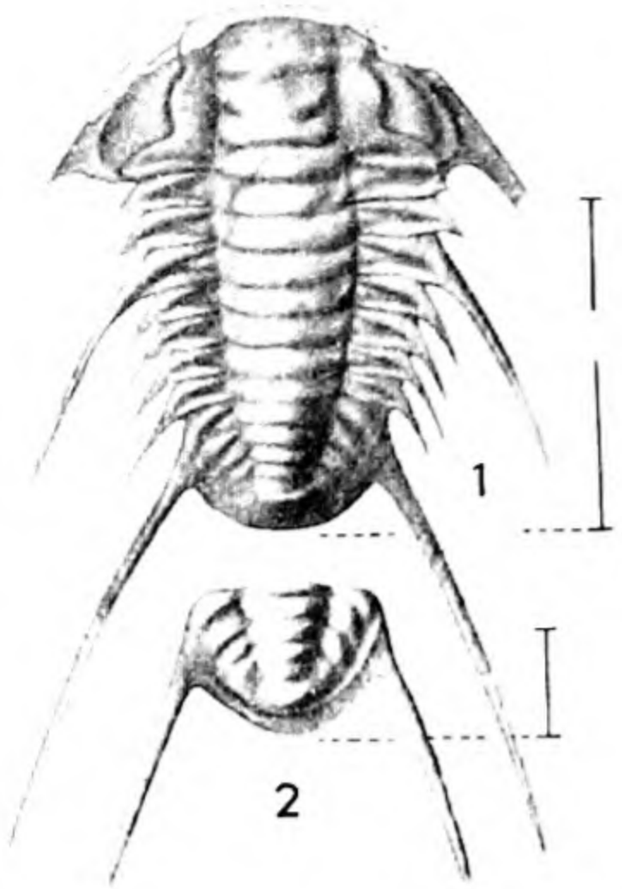
ORYCTOCEPHALITES Resser 1939

(**O. typicalis*). Differs from *Oryctocephalus* in having a less quadrate cranidium and greater fusion in pygidium so that grooves are eliminated; spines are also shorter and stouter. **M. Camb.** (Cordilleran region)

PLATE 257

[Figures are x1 unless otherwise indicated; photographs for all except 6 and 23 furnished by C. E. Resser.]

1–5. Kootenia spp. **1–4. K. convoluta.** Cephalic and pygidial views of an enrolled specimen; a well preserved pygidium. **5. K. currieri. 6. K. dawsoni** [SMC 67 (4)]. A somewhat broken and crushed specimen (x2). **7–9. Prozacanthoides** spp. **7. P. virginicus. 8, 9. P. optatus** [SMC 98 (24)]. Pygidium (x4); cephalon and part of thorax (x3). **10, 11. Kootenia marcoui.** Crushed cranidium; pygidium. **12, 13. Kochaspis coosensis.** Cranidium and pygidium. **14, 15. Oryctocephalites typicalis** [SMC 98 (24)]. Pygidium (x4) and cranidium (x5). **16. Kochaspis illiana.** Cranidium. **17–19. Kochaspis dispar.** Two cranidia, showing variation in preservation, and a pygidium. **20–22. Zacanthoides typicalis.** A well preserved pygidium to which is attached the last thoracic segment; a well preserved specimen; Walcott's early figure of the type specimen (x2) [USGS, B 30]. **23. Oryctocephalus reynoldsi.** Entire dorsal shield (x2). **24, 25. Zacanthoides romingeri.** Two specimens nearly complete except for free cheeks.



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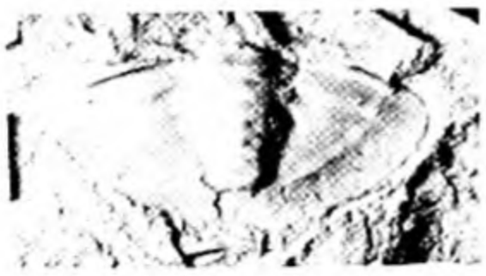

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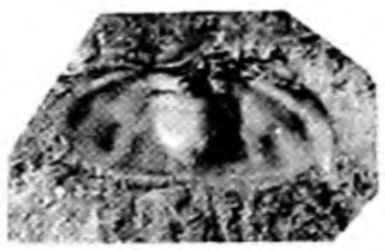

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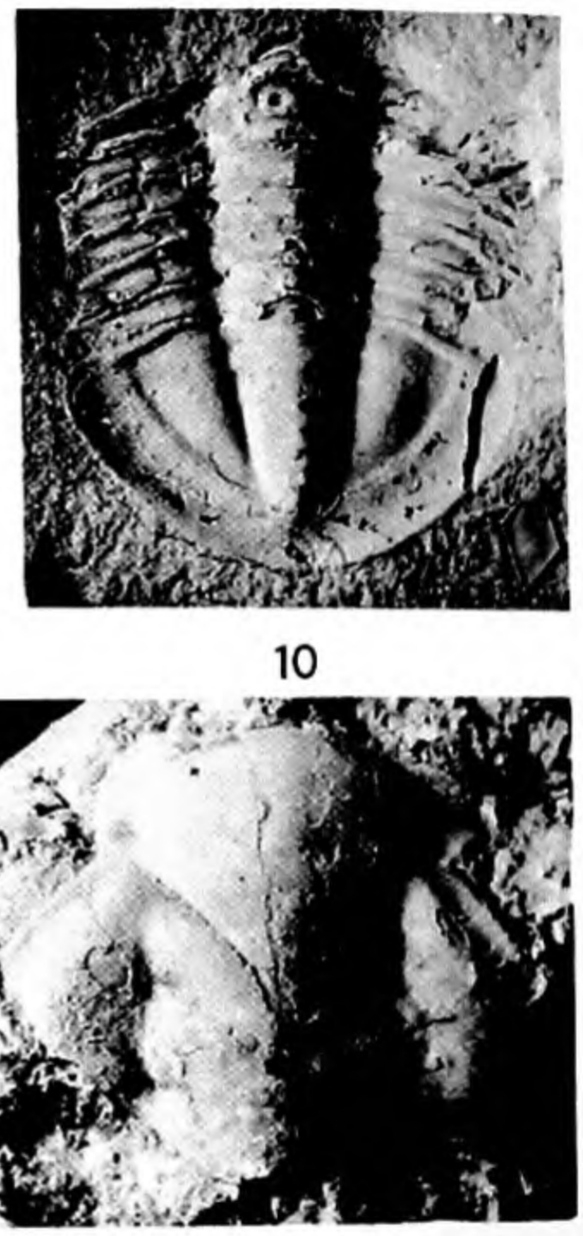

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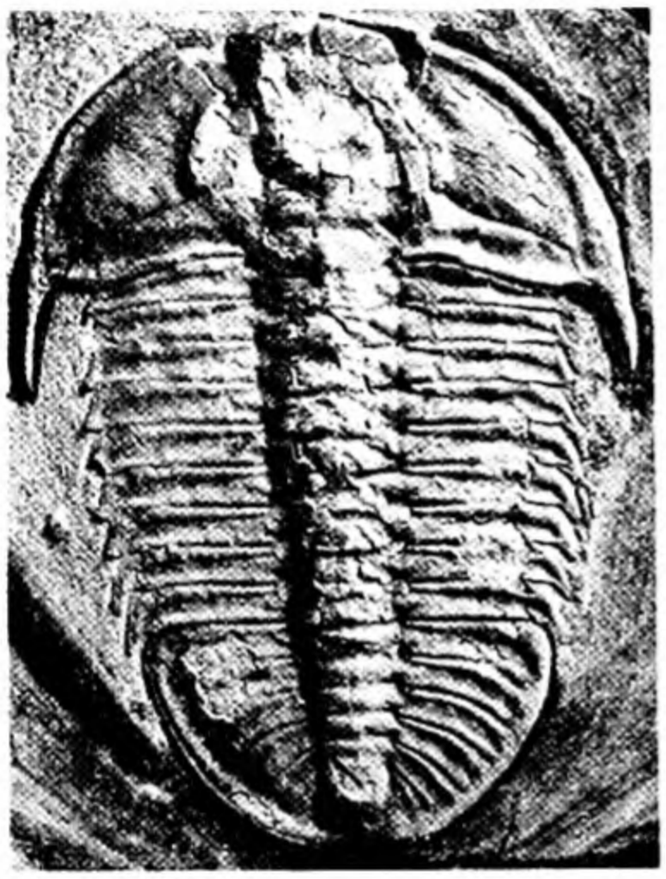

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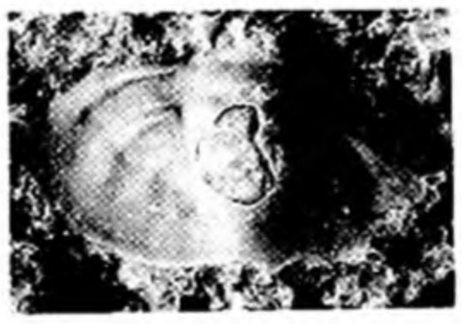

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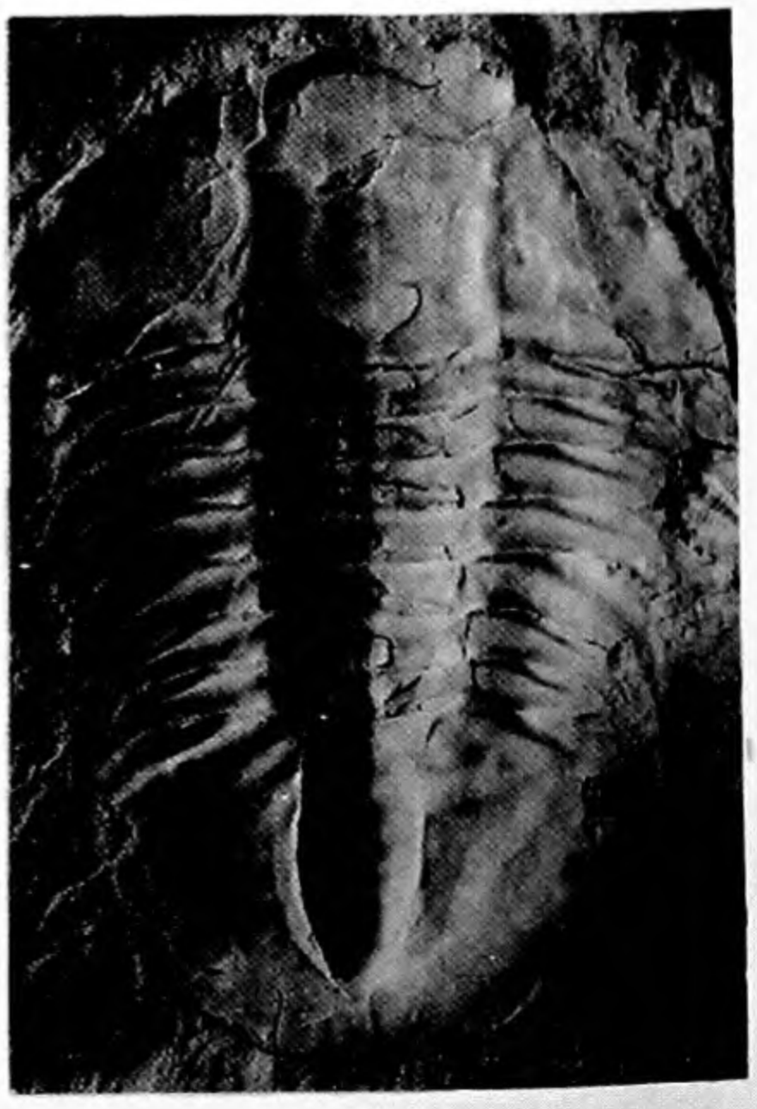

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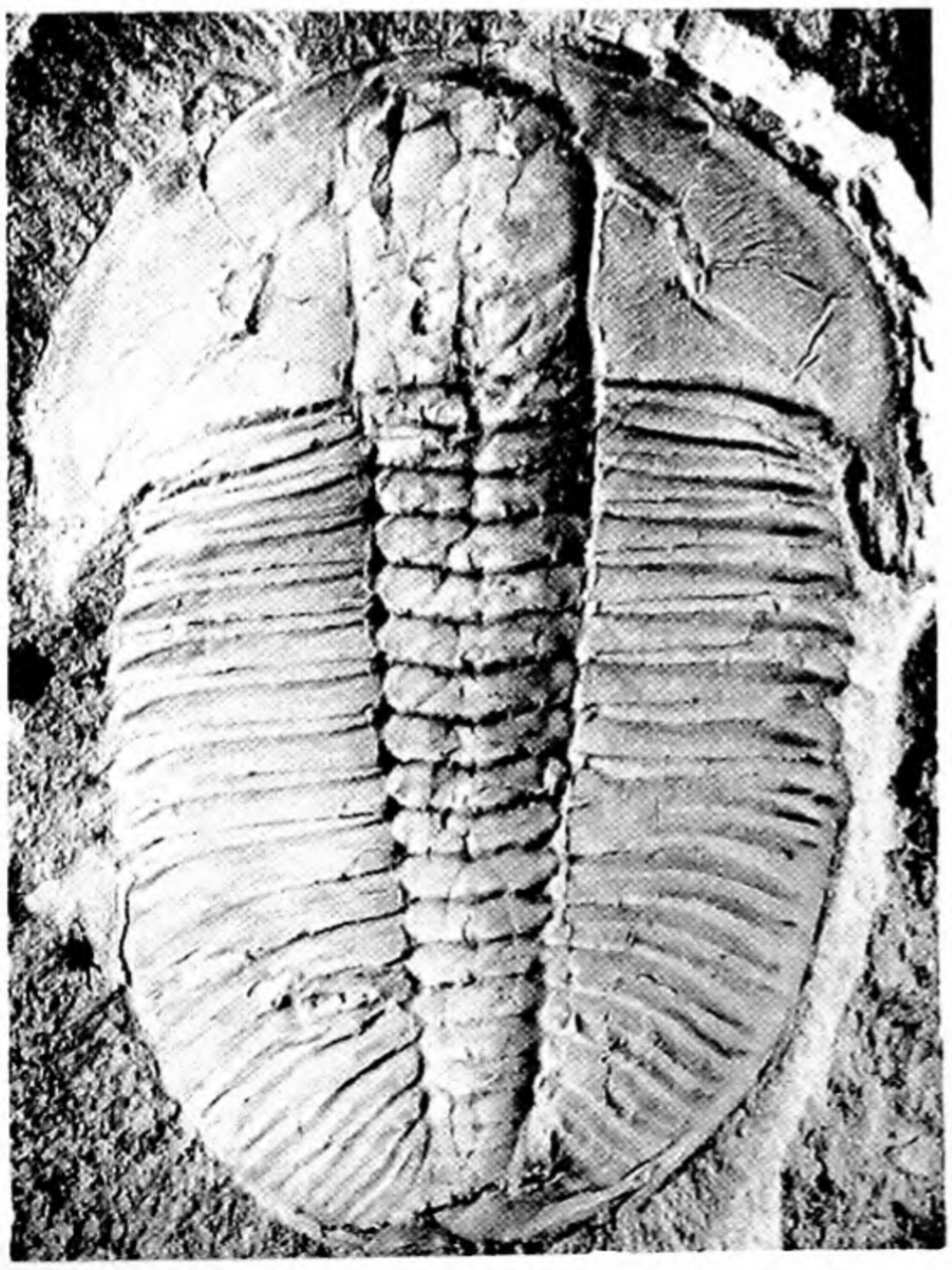

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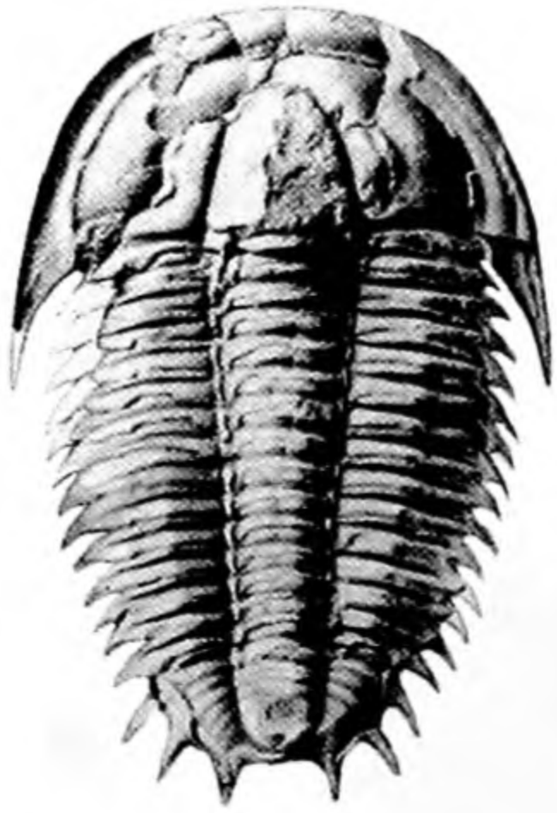

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***O. typicalis** Resser (**257**—14, 15). **Langston:** Wasatch Mts.

ORYCTOCEPHALUS Walcott 1886

(**O. primus*). Cranidium quadrate; glabella long, parallel sided, with three pairs of pits; rim narrow, particularly in front of glabella: eyes large; pygidium with long, sharp marginal spines. **M. Camb.** (Cordilleran region; Asia; Australia).

O. reynoldsi Reed (**257**—23). **Stephen:** B. C.

PACHYASPIS Resser 1939

(**P. typicalis*). Cranidium strongly convex; glabella tapers slowly forward; occipital ring with small nuchal spine; strong brim. **M. Camb.** (western N. America).

***P. typicalis** Resser (**255**—7, 8). **Langston:** Wasatch Mts.

PAEDEUMIAS Walcott 1910

(**P. transitans*). Like *Olenellus*, but glabella does not reach rim; hypostoma attached by stalk; macropleural development of 3rd thoracic segment and large axial spine on 15th rudimentary segments simple; pygidium rounded. **L. Camb.** (Vt., Pa., Nev.).

***P. transitans** Walcott (**254**—18). **Parker:** Vt.

PAGETIA Walcott 1916

(**P. bootes*). Small, nearly isopygous trilobites with three thoracic segments; glabella clearly defined, with or without a long occipital spine; glabellar furrows short; free cheeks small; eyes small, situated near margin; numerous transverse depressions inside rim; subcylindrical axial lobe full length of pygidium with five or more well defined segments; posterior lobe frequently extended into a spine; pleural furrows present or absent. **M. Camb.** (S. Appalachians and Cordilleran region; Australia).

***P. bootes** Walcott (**252**—7–9). **Burgess, Stephen:** B. C.

P. clytia Walcott (**252**—13–15). **Spence:** Wasatch Mts.

PARADOXIDES Brongniart 1822

(**P. tessini*). Glabella enlarged anteriorly with two to four pairs of furrows; eye lobe usually large; thorax long; pygidium small. **M. Camb.** (Atlantic Province)

P. hicksi Salter (**254**—9, 10). **Menevian:** Newf. (Long Pond).

P. davidis Salter (**254**—12, 13; **300**—13, 14). **Menevian:** Newf. (Kelligrew Brook).

P. abenacus Matthew (**254**—8). **Menevian:** N. B. (Porter Road).

P. matthewi Howell (**254**—11). **Menevian:** N. B. (Hastings Cove).

P. lamellatus Dawson (**254**—14, 15; **276**—19). **M. Camb.:** Newf. (Chamberlin's Brook); N. B. (Fossil Brook).

P. eteminicus Matthew (**254**—1, 2). **M. Camb.:** Newf. (Chamberlin's Brook); N. B. (Fossil Brook).

P. harlani Green (**254**—3–7). **M. Camb.:** Mass. (Braintree).

PEACHELLA Walcott 1910

(**Olenellus iddingsi*). Glabella slender, with slightly swollen front lobe; eyes rather small; fixed cheeks swollen; brim widening to heavy genal spines; thorax unknown. **L. Camb.** (southwestern U. S. A.).

***P. iddingsi** (Walcott) (**254**—17). **Pioche:** Nev.

POLIELLA Walcott 1916

(**Bathyuriscus* (*Poliella*) *anteros*). Differs from *Bathyuriscus* in having smaller and smoother pygidium. **L.** and **M. Camb.** (N. America).

***P. anteros** (Walcott) (**256**—2, 3). **M. Camb.:** Wasatch Mts. (Spence).

POULSENIA Resser 1936

(**Solenopleura grönwalli* Poulsen). Small; cranidium wide, convex in both directions; glabella well defined, with two or three pairs of short furrows; brim consisting of a more or less thickened rim; preglabellar area variable. **L.** and **M. Camb.** (Greenland; western N. America).

P. cossus (Walcott) (**259**—4, 5). **L. Camb.:** B. C.

P. granosa Resser (**259**—6, 7). **M. Camb.:** Wasatch Mts.

PROLIOSTRACUS Poulsen 1932

(**P. strenuelliformis*). Distance between glabella and anterior margin relatively great; glabella more or less conical, truncate in front; posterior branch of facial suture relatively long, longer than palpebral lobe; glabella and fixed cheeks strongly elevated; circumglabellar furrow in rather deep depression. **L. Camb.** (Greenland; eastern N. America).

P. goodwini Resser (**255**—10, 11). **Shady:** Va.

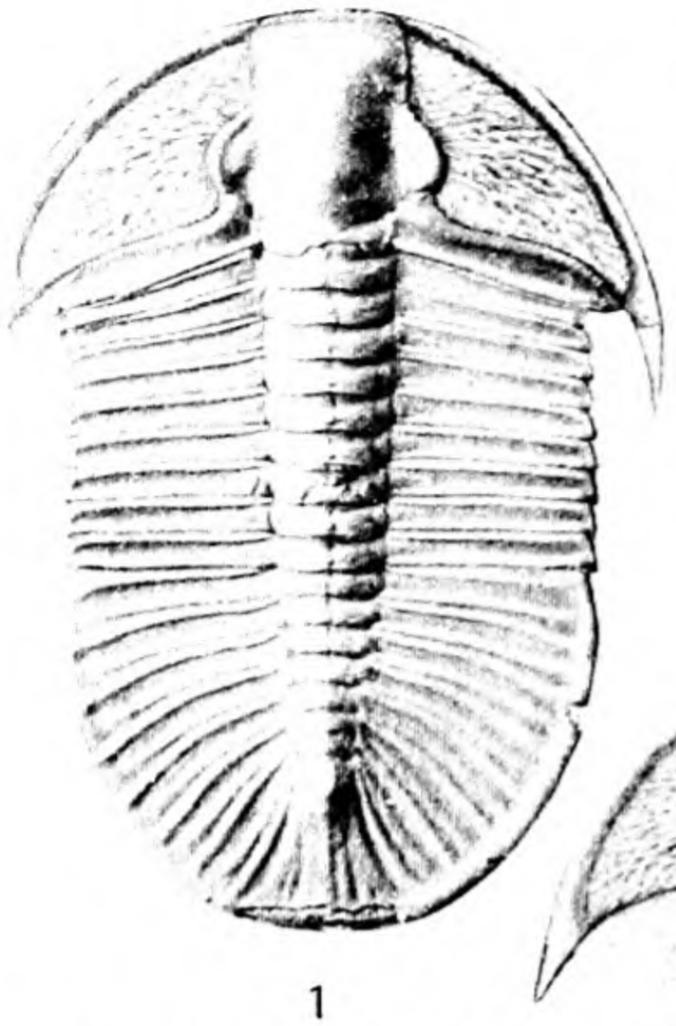
PROTOLENUS Matthew 1892

(**P paradoxides*). Glabella cylindro-conical, marked

PLATE 258

[Figures are x1 unless otherwise indicated; photographs for all figures except 1, 2, 11, and 17 were furnished by C. E. Resser; Walcott figured many of the specimens shown here, and in such instances the place of publication is indicated.]

1–3. Albertella helena. A complete specimen, and a pygidium (posterior part of spines cut off) [SMC 53 (2)]; pygidium. **4, 5. Glossopleura producta.** Cranidium and pygidium. **6–8. Ptarmigania rossensis.** Cranidium, pygidium, and a nearly complete specimen with the typical long genal spines. **9. Asaphiscus wheeleri** [SMC 64 (5)]. A medium-sized specimen, somewhat broken by compression in shale. **10. Glossopleura boccar.** Posterior portion of thorax and the pygidium. **11, 12. Bathyuriscus** spp. **11. B. formosus** (x1.5) [GSA, SP 18]. Holotype. **12. B. rotundatus. 13, 14. Ptarmigania germana** (x1.5) [SMC 98 (24)]. Holotype cranidium; pygidium. **15. Dollchometopsis gravis** [SMC 98 (24)]. Holotype cranidium (x1.5). **16. Ogygopsis klotzi** [SMC 64 (5)]. Large, compressed specimen. **17. Marjumia typa** [SMC 64 (5)]. Entire dorsal shield of type. **18. Anoria tontoensis** [SMC 64 (5)]. A nearly complete dorsal shield viewed from ventral side.



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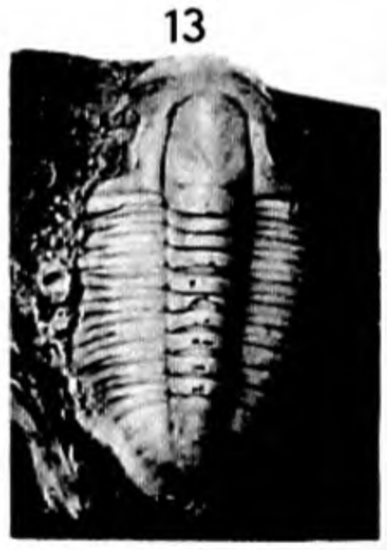

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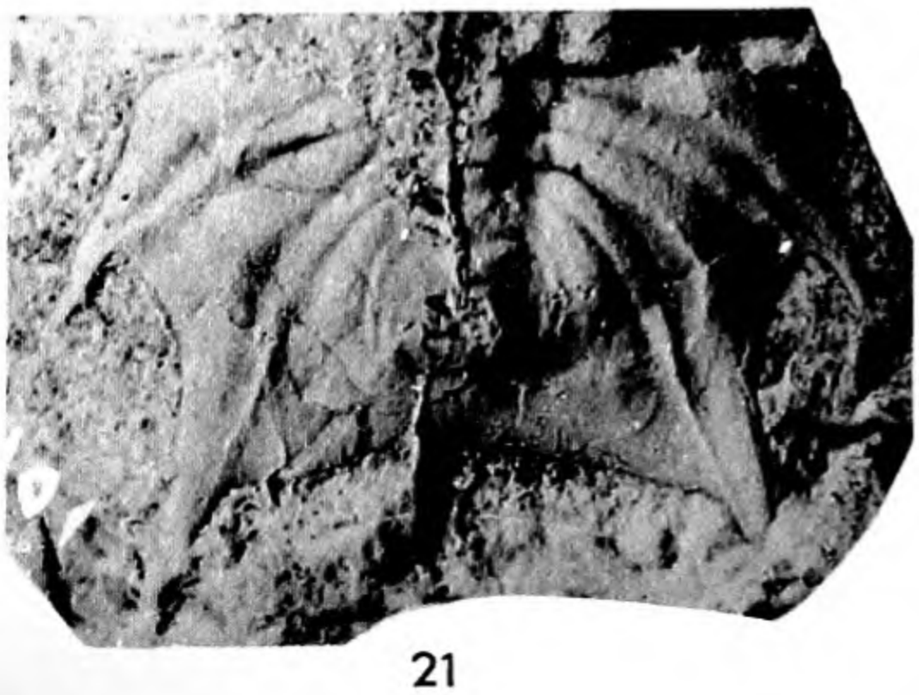

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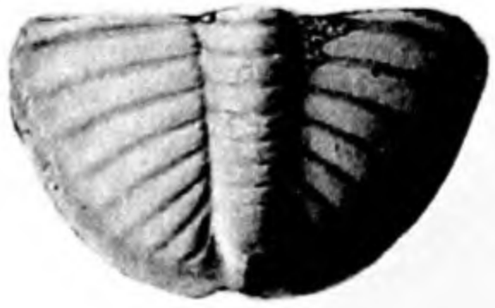

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by three pairs of furrows; eye lobes long and narrow. **L. Camb.** (Atlantic Province).

***P. paradoxides** Matthew. **Hanford Brook:** N. B.

P. (Bergeronia) elegans Matthew (**253**—9). Pleura strongly bent downward. **Hanford Brook:** N. B.

PROZACANTHOIDES Resser 1937

(**Olenoides stissingensis* Dwight). Glabella large, rectangular, with three pairs of short furrows; occipital furrow straight and clearly impressed, occipital spine present; facial sutures strongly divergent anterior to the large eyes; brim concave; pygidium with prominent, annulated axial lobe and with pleura turning sharply backward and terminating in blunt spines. **L.** and **M. Camb.** (N. America).

P. virginicus Resser (**257**—7). **L. Camb.:** Va. (Shady).

P. optatus Resser (**257**—8, 9). **M. Camb.:** Wasatch Mts. (Langston).

PTARMIGANIA Raymond 1908

(**Bathyuriscus rossensis* Walcott). Glabella large, with four pairs of furrows and expanded anteriorly in some species; fixed cheeks narrow, free cheeks small with very long genal spines; eyes large; brim narrow; nine thoracic segments; pygidium large, well fused; axial lobe with four to five segments; two to three pleural furrows visible, and in some species ending in deep pits; pygidial border wide. **M. Camb.** (Cordilleran region).

***P. rossensis** (Walcott) (**258**—6–8). **Ptarmigan:** B. C.

P. germana Resser (**258**—13, 14). **Langston:** Wasatch Mts.

PTYCHOPARELLA Poulsen 1927

(**P. brevicauda*). Pygidium extremely short, having a very short axial lobe with but four segments and with well differentiated border. **L. Camb.** (N. America).

P. adamsi (Billings) (**259**—10, 11). Ocular ridge well developed; glabella nearly parallel sided. **L. Camb.:** Que.; Vt.

P. billingsi Resser (**259**—9). **L. Camb.:** Vt. (Winooski?).

SOLENOPLEURELLA Poulsen 1927

(**S. ulrichi*). Cephalon convex, with thickened upturned lip; glabella long, tapering forward, with three pairs of furrows. **M. Camb.** (Greenland; N. America).

***S. ulrichi** Poulsen. **Cape Wood:** Greenland.

S. buttsi Resser (**255**—22). **Rutledge:** S. Appalachians.

STRENUELLA Matthew 1887

(**Agraulos strenuus* Billings). Differs from *Agraulos* in its elevated glabella, concave brim and long eye lobes; neck ring with a broad, triangular, backward pointing spine; pleura strongly angular dorsoventrally. **L. Camb.** (Atlantic Province).

***S. strenua** (Billings) (**253**—18). **L. Camb.:** Newf.; Mass.

TAXIOURA Resser 1939

(**T. typicalis*). Glabella large, rectangular in outline, occupying nearly full length of cranidium; glabellar furrows faint; brim narrow, concave, and without rim; eye lines conspicuous; genal spines long; surface of ocular platform covered with fine anastomosing lines; pygidium with narrow axial lobe which occupies full length of pygidium and is differentiated into about 10 rings; pleural furrows conspicuous and straight; ribs without grooves. **M. Camb.** (Cordilleran region).

***T. typicalis** Resser (**259**—23, 24). **Langston:** Wasatch Mts.

THOMPSONASPIS Deiss 1939

(**T. obscura*). Cranidium longitudinally concavo-convex, length greater than width between eyes, surface granulose; brim marked by irregular longitudinal lines; glabella subtrapezohedral; glabellar furrows in three pairs, strong; dorsal furrows strong, shallow in front of glabella; three depressions or puncta in dorsal furrow anterior to glabella; brim wide, concave; rim upturned; eye ridges strong. **M. Camb.** (Cordilleran region).

***T. obscura** Deiss (**256**—8–10). **Steamboat:** Mont.

TONKINELLA Mansuy 1916

(**T. flabelliformis*). Cranidium subtrapezohedral: glabella parallel sided or expanded forward, elevated above the cheeks; frontal margin of glabella rounded and overlapping upon frontal brim; glabellar furrows in three pairs; fixed cheeks slightly convex; eye lines obsolete; facial suture nearly straight; brim narrow, flat. **M. Camb.** (N. America; Asia).

PLATE 259

[Figures are x1 unless otherwise indicated; photographs for all figures except 1, 2, 4, 5, 12, and 13 were furnished by C. E. Resser.]

1, 2. Orria elegans [SMC 64 (5)]. The type specimen, a dorsal shield, with free cheeks restored; a typical free cheek. **3. Clavaspidella howelli. 4–7. Poulsenia spp. 4, 5. P. cossus** (x3) [SMC 98 (24)]. Outline of side view and dorsal view of type cranidium. **6, 7. P. granosa** [SMC 98 (24)]. Cranidium (x1.5) and pygidium (x4). **8. Oryctocara geikiei** [SMC 53 (2)]. Specimen with cranidium and pygidium displaced with respect to thorax. **9–11. Ptychoparella spp. 9. P. billingsi.** Incomplete cranidium (x2). **10, 11. P. adamsi.** Cranidia (x2, x1). **12, 13. Andrarina tenera** [USGS, B 10]. Cranidia, somewhat enlarged. **14–16. Glyphaspis capella.** Cranidium, pygidium, and a fairly complete specimen. **17, 18. Bicaspis typica.** Cranidium (x1.5) and pygidium (x2). **19. Blainia gregaria.** Specimen complete except for free cheeks. **20, 21. Holteria problematica.** Cranidium and pygidium. **22. Clavaspidella anax.** Complete but somewhat crushed specimen. **23, 24. Taxioura typicalis** (x1.5) [SMC 98 (24)]. Holotype cranidium, and pygidium; well preserved pygidium. **25, 26. Vanuxemella contracta.** Walcott's restored figure of a crushed dorsal shield (x2.5) [SMC 64 (3)]; photograph of a nearly complete specimen (x2). **27, 28. Tonkinella stephensis** (x2.5). Complete specimen; pygidium.

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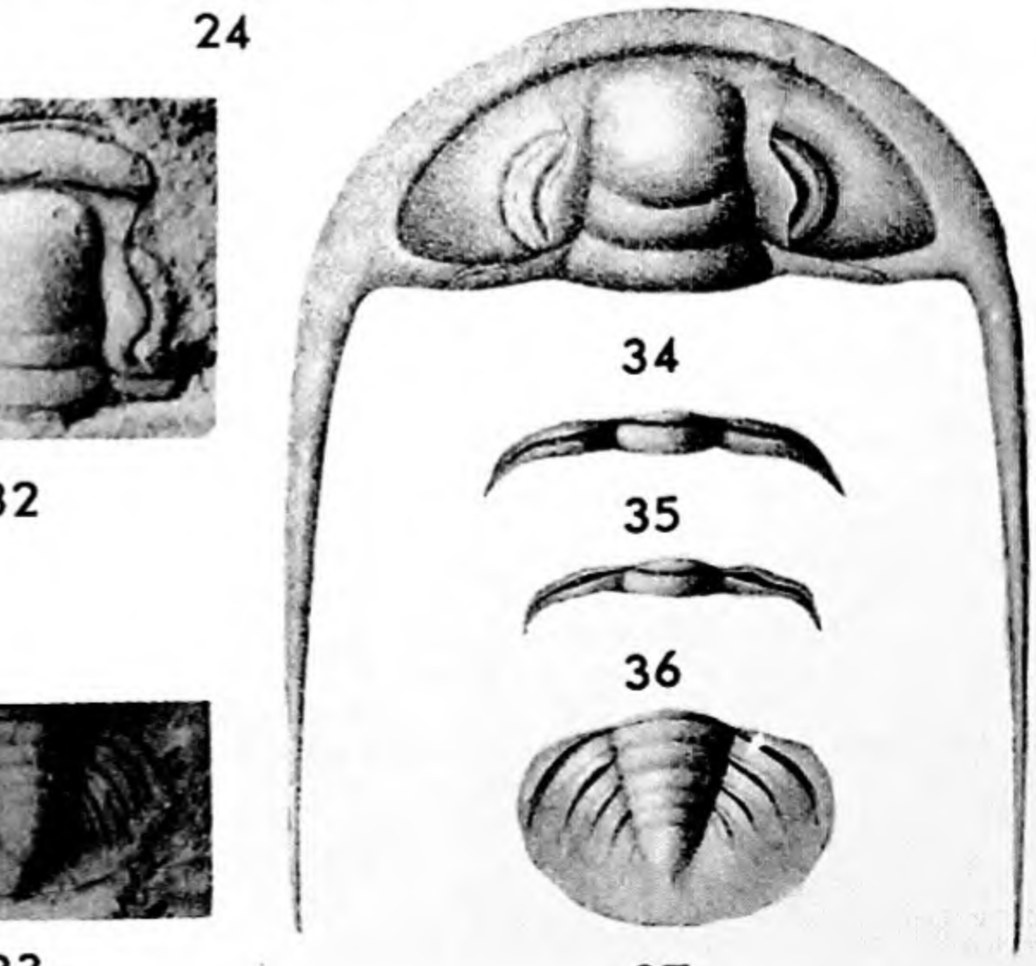

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T. stephensis Kobayashi (**259**—27, 28). **Stephen:** B. C.

VANUXEMELLA Walcott 1916

(**V. contracta*). Small trilobites with large, quadrangular glabella extending full length of cranidium, slightly expanded in forward portion; fixed cheeks average half glabellar width; eyes of moderate size; narrow rim on fixed cheeks; six thoracic segments ending in blunt spines; pygidium with large axial lobe and with anterior axial rings and pleural furrows present in some species; a pair of posteromarginal spines. **M. Camb.** (Cordilleran region).

***V. contracta** Walcott (**259**—25, 26). **Gordon:** Mont.

WANNERIA Walcott 1910

(**Olenellus* (*Holmia*) *walcottanus* Wanner). Frontal glabellar lobe expanded, reaching rim; eye lobes smaller than in *Olenellus;* thorax wide; fifteen segments with axial nodes; two segments reduced; pygidial plate bilobed; surface reticulate. **L. Camb.** (N. America).

***W. walcottana** (Wanner) (**253**—20). **Kinzers:** Pa.

WEYMOUTHIA Raymond 1913

(**Agnostus? nobilis* Ford). Cephalon and pygidium smooth and of same size, without dorsal furrows, but with brim and flange; no spines; three thoracic segments. **L. Camb.** (eastern N. America; Norway).

***W. nobilis** (Ford) (**252**—16). Seven to eight tubercles on brim on each side of cephalon. **L. Camb.:** Mass., N. Y. (Schodack).

ZACANTHOIDES Walcott 1888

(**Olenoides spinosus*). Cranidium narrow, consisting of large, nearly rectangular glabella, large palpebral lobes and brim; three or four pairs of glabellar furrows; eyes large, extending nearly to rear margin; anterior facial sutures diverge considerably; brim simple, concave; eight or nine thoracic segments, with long spine on eighth in some species; pleura loosely arranged with sharp points; pygidium small, with wide tapering axial lobe extending to rear margin; axial furrows well developed, prominent; pleural furrows shallow; each individual rib extends into slender marginal spine. **M. Camb.** (widespread throughout N. America).

Z. romingeri Resser (**257**—24, 25). **Stephen:** B. C.

Z. typicalis Walcott (**257**—20–22). **Chisholm:** Nev.

UPPER CAMBRIAN TRILOBITA

[Genera arranged alphabetically]

ACHEILOPS Ulrich 1930

(**A. dilatus*). Cranidium without brim in front of glabella or eyes; glabellar furrows short, variable in number, from none to four pairs; eyes very large, the anterior ends of the palpebral lobes attached to glabella. **U. Camb.** (central U. S. A.).

***A. dilatus** Ulrich (**263**—9–11). Two pairs of glabellar furrows. **Eminence:** Mo.

ACHEILUS Raymond 1924

(**A. marcoui*). Glabella almost square, expanding slightly forward; no brim; anterior glabellar furrows faint or absent, the other two pairs more prominent but short. **U. Camb.** (N. America).

***A. marcoui** Raymond (**263**—8). **Gorge:** Vt.

APHELASPIS Resser 1935

(**Conocephalites depressus* Shumard). Cranidium long and narrow, flaring at front, with wide brim and thickened rim; posterolateral limbs narrow; pygidium short and wide. **U. Camb.** (S. Appalachians [Nolichucky] Wis. [Eau Claire], Tex. [Cap Mt.], western U. S. A.).

***A. depressus** (Shumard) (**263**—35, 36). **Wilberns:** Tex.

A. hamblenensis Resser (**263**—37). **Nolichucky:** Tenn.

A. walcotti Resser (**263**—31). **Nolichucky:** Tenn.

ARAPAHOIA Miller 1936

(**A. typa*). Resembles *Plethopeltis* but has a more triangular head, a tapering glabella, and wider posterolateral limbs. **U. Camb.** (Newf.; Cordilleran region).

***A. typa** Miller (**263**—17, 18). **Boysen:** Wyo.

A. ransomei Stoyanow (**263**—15, 16). **Abrigo:** Ariz.

A. prolixa Resser (**263**—19, 20). **Sullivan:** Canadian Rockies.

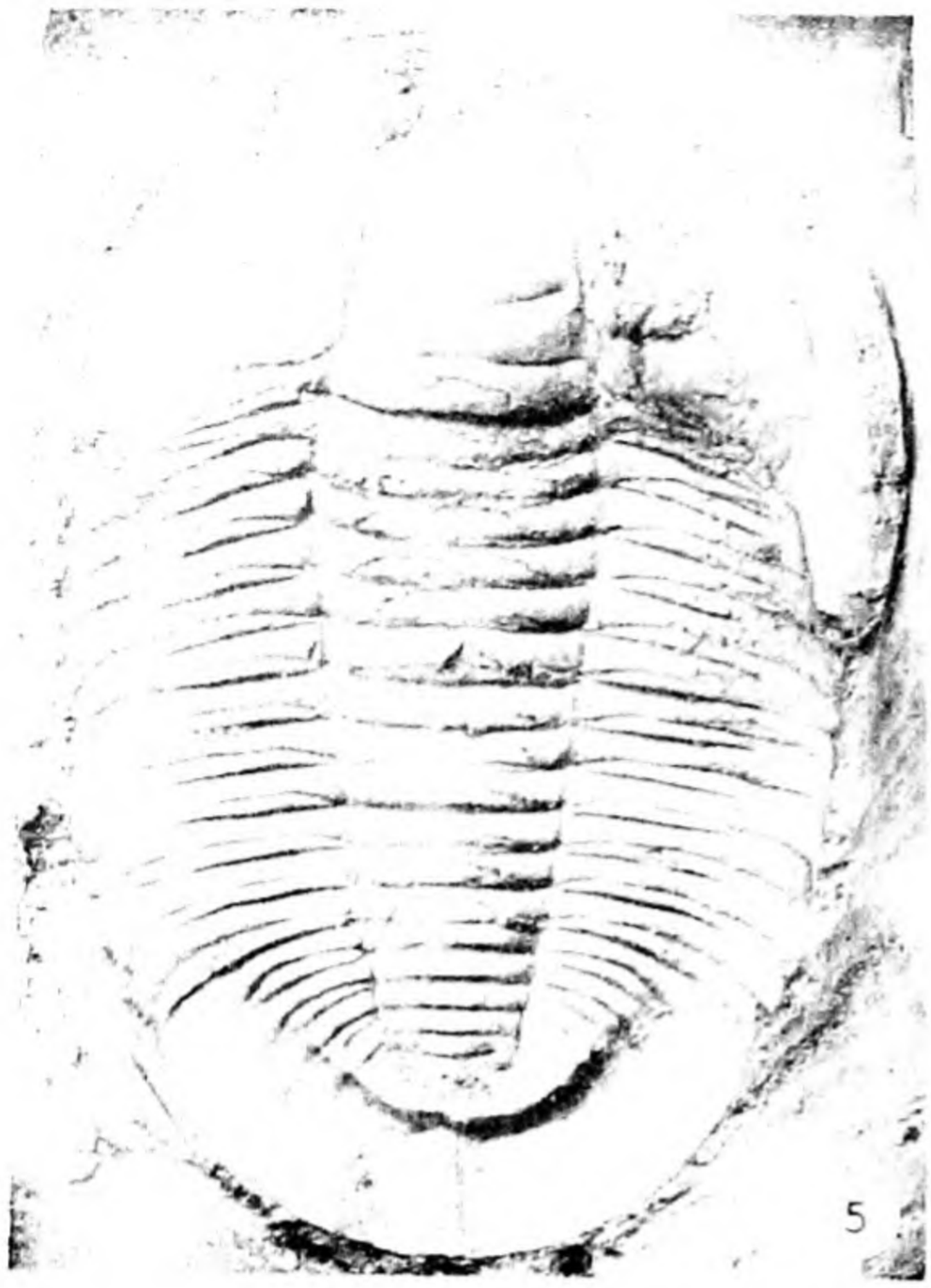
BLOUNTIA Walcott 1916

(**B. mimula*). A relatively short, conical, gently tapering glabella which lacks furrows; broad pos-

PLATE 260

[Figures are x1 unless otherwise indicated; photographs furnished by Resser are indicated by CER; those by Bridge, JB.]

1–3. Plethopeltis saratogensis [CER]. Cranidium (x2); pygidium (x2.5); free cheek (x2). **4, 5. Plethopeltis buehleri** [Mo G S 24; JB]. Side and dorsal views of cranidium. **6, 7. Plethometopus convexus** [Mo G S 24; JB]. Side and dorsal views of cranidium. **8–11. Stenopilus** spp. **8, 9. S. latus** [Mo G S, 24; JB]. Side and dorsal views of cranidium. **10, 11. S. pronus** (x1.3) [Vt G S 14]. Side view, in outline, and dorsal view of cranidium. **12–14. Camaraspis convexa** [CER]. Pygidium, and two cranidia. **15–19. Illaenurus** spp. **15. I. albertensis** [CER]. Incomplete cranidium. **16–19. I. quadratus** (x1.5) [SMC 64 (5)]. Dorsal view of cranidium; well preserved cephalon; dorsal and side views of a complete dorsal shield. **20–25. Platycolpus** spp. **20, 21. P. whitfieldi** [CER]. Cranidium and pygidium. **22, 23. P. sinclairensis** [CER]. Two pygidia showing variation in shape. **24, 25. P. capax** [CGS, Pal Fos 1]. Longitudinal section of cranidium, with front margin at *a*; dorsal view of cranidium. **26–29. Saukiella typicalis** [Mil Pub Mus, B 12]. Two cranidia; side and dorsal views of pygidium. **30. Saukia acuta** [Mil Pub Mus, B 12]. Dorsal view of complete specimen. **31–37. Saukiella pepinensis.** 31–33: Genal spine, holotype cranidium, and pygidium [Mil Pub Mus, B 12]. 34–37: Hall's figures [N Y St Cab 16]; restored figure of cephalon; thoracic segments; pygidium.



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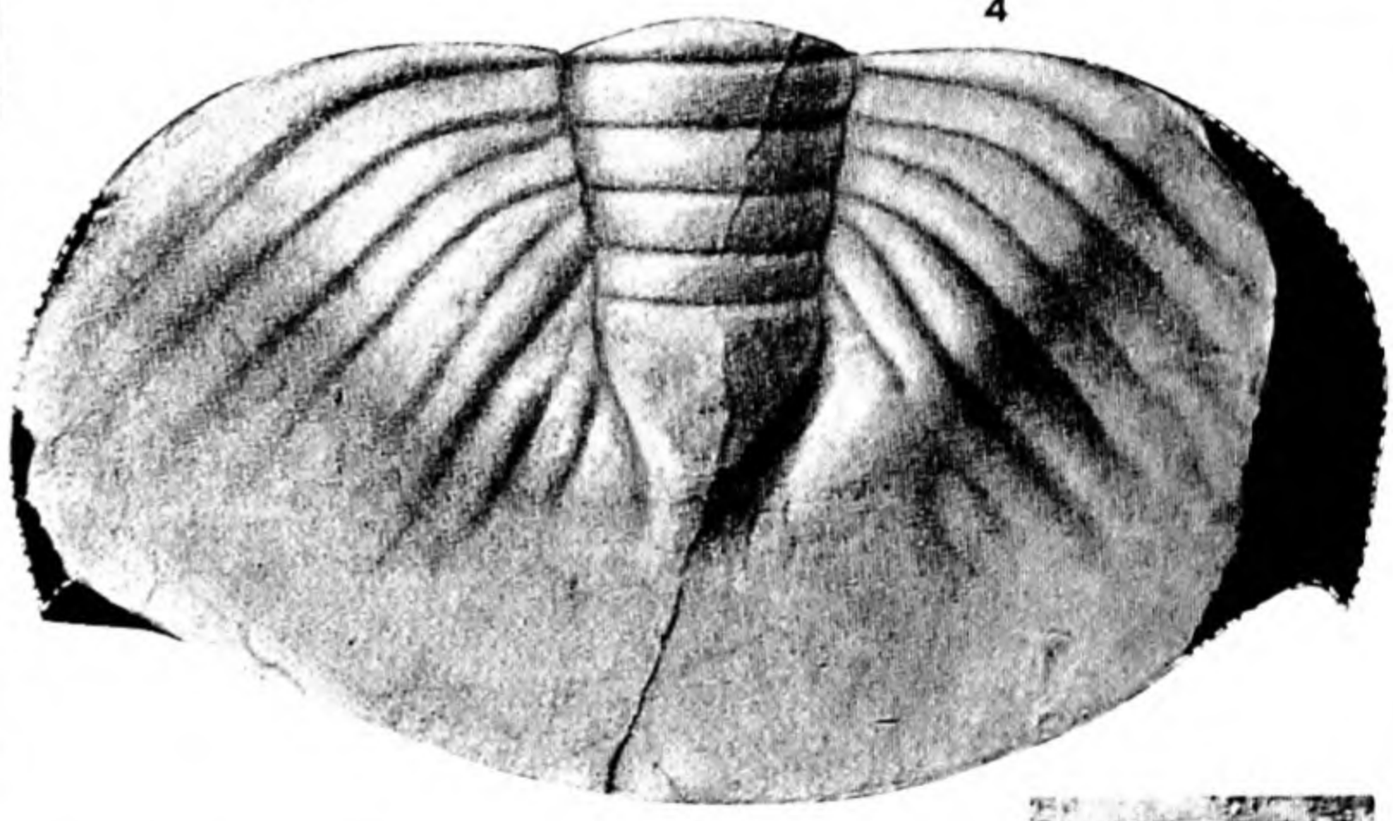

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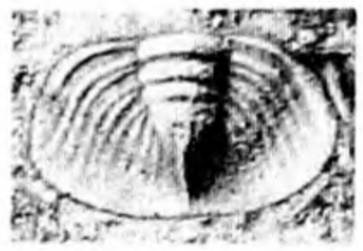

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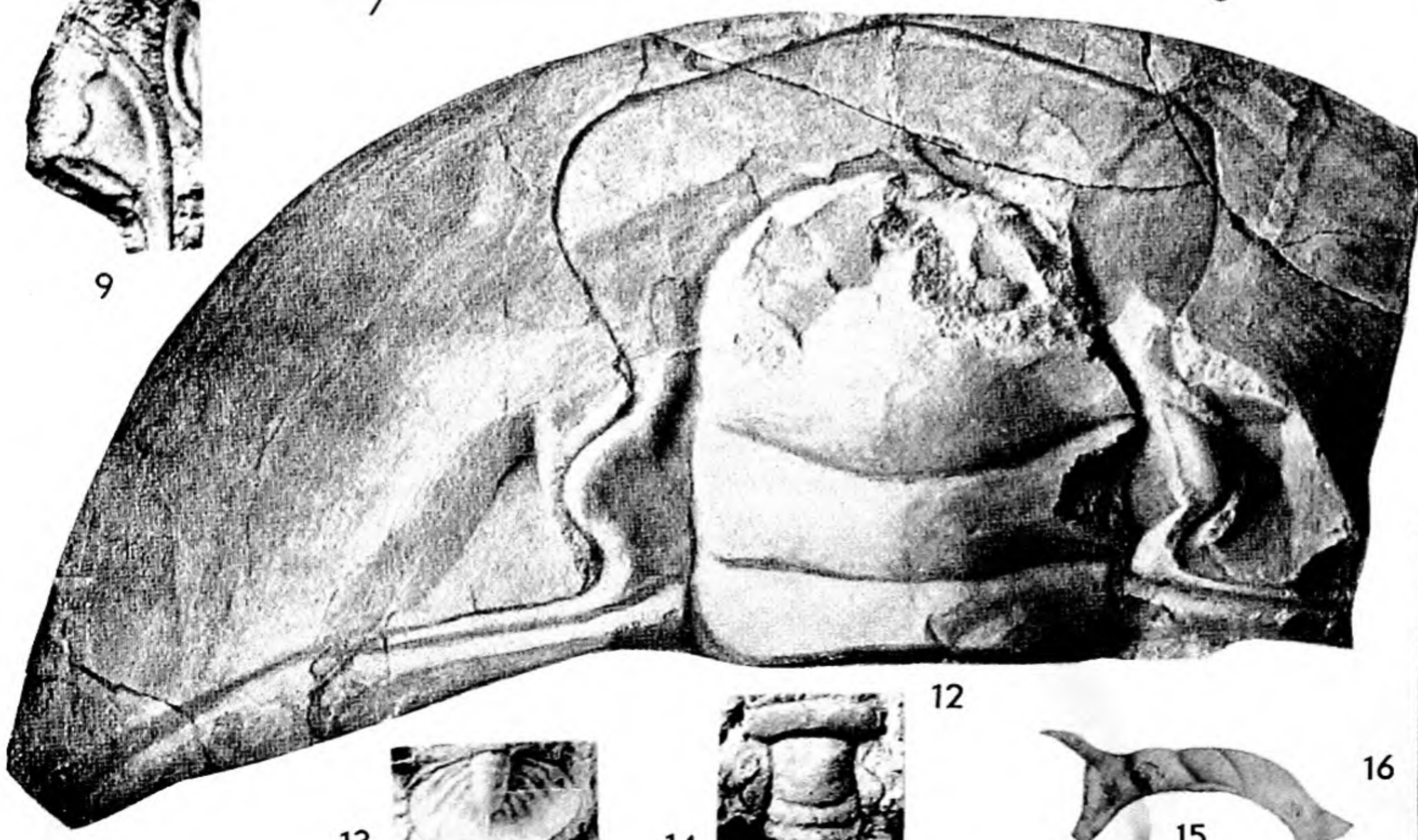

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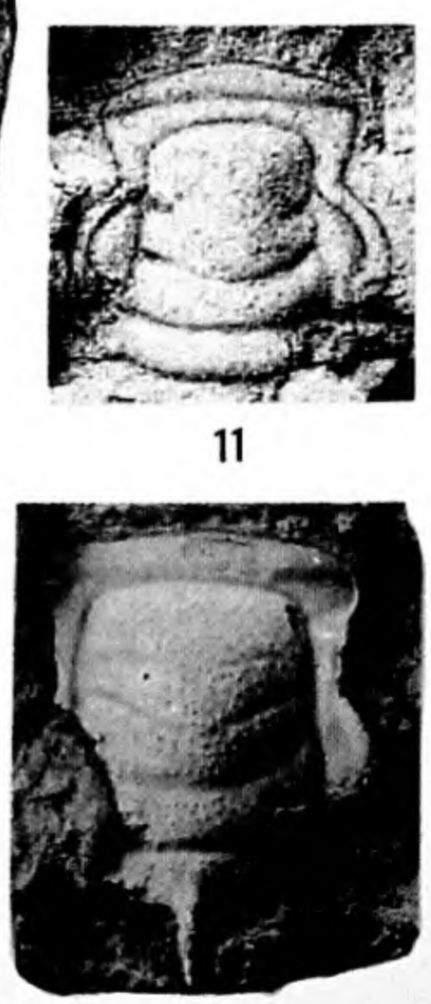

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terolateral limbs; pygidium semioval, with axial lobe about two-thirds of pygidial length, axial and pleural lobes smooth. **U. Camb.** (N. America).

***B. mimula** Walcott (**263**—3, 4). **U. Camb.:** ?Newf.; Tenn. (Nolichucky).

BRASSICEPHALUS Lochman 1940

(**B. pulchellus*). Cranidium small, wide; glabella subquadrate, parallel sided with rounded front, no furrows; fixed cheeks wide; palpebral lobes small; frontal limb extremely narrow, border narrow and abruptly downturned; posterolateral limbs short and wide with a narrow, well defined intramarginal furrow widening and swinging forward near suture line; outer surface of test smooth, inner finely punctate. **U. Camb.** (widespread in western U. S. A.).

***B. pulchellus** Lochman (**263**—21–23). **Bonneterre:** Mo.

BRISCOIA Walcott 1924

(**B. sinclairensis*). Glabella broadly rounded in front and strongly convex; frontal lobe smooth, sloping abruptly down to faint dorsal furrows which are narrow but distinct; differs from *Dikelocephalus* in its elongate glabella, brim, and course of facial sutures in front of eyes. **U. Camb.** (N. America).

***B. sinclairensis** Walcott (**262**—29–31). **Franconia** and equivalents: Wis., Minn., Alta., B. C.

BURNETIA Walcott 1924

(**Ptychoparia? urania*). Cranidium distinguished by the peculiar triangular frontal expansion of the brim. **U. Camb.** (western N. America).

***B. urania** (Walcott) (**263**—25, 26). **Wilberns:** Tex.

B. extensa Resser (**263**—24). **Signal Mt.:** Okla.

BYNUMIA Walcott 1924

(**B. eumus*). Cranidium subtriangular, produced at the front; glabella nearly smooth, with faint dorsal furrow except when exfoliated; many species. **U. Camb.** (western U. S. A.).

***B. eumus** Walcott (**263**—34). **U. Camb.:** Mont. (Pilgrim); Alta. (Sullivan).

B. robsonensis Resser (**263**—32, 33). **U. Camb.:** B. C.

CALVINELLA Walcott 1914

(**Dikelocephalus spiniger* Hall). Differs from *Tellerina* in having an occipital spine. **U. Camb.** (N. J. [Kittatinny], U. Mississippi Valley, Mo. [Eminence], ?Tex. [L. Ellenburger]); **L. Ord.**

***C. spiniger** (Hall) (**261**—13, 14). **Trempealeau:** U. Mississippi Valley.

C. ozarkensis Walcott (**261**—15, 16). **Eminence:** Mo.

CAMARASPIS Ulrich and Resser 1924

(**Arionellus convexus* Whitfield). Differs from *Plethopeltis* in the smaller, elevated truncato-conical glabella, larger and more posterior eyes, and a faint development of a rim on the convex brim. **U. Camb.** (widespread throughout N. America).

***C. convexa** (Whitfield) (**260**—12–14). **Ironton:** U. Mississippi Valley.

CEDARIA Walcott 1924

(**C. prolifica*). Characterized by proparianlike course of facial suture; free cheeks commonly have long genal spines and are frequently attached strongly enough to remain a unit with the cranidium. **U. Camb.** (widespread throughout N. America).

***C. prolifica** Walcott (**264**—3–7). **Nolichucky:** Ala.

C. woosteri Whitfield (**264**—8–10). **Eau Claire:** Wis.

C. minor (Walcott) (**264**—1, 2). **Weeks:** Utah.

CHARIOCEPHALUS Hall 1863

(**C. whitfieldi*). Glabella rectangular; facial sutures diverge widely in front of eyes; short, narrow posterolateral limbs; rim and brim subequal in width; many species. **U. Camb.** (central and western U. S. A.).

***C. whitfieldi** Hall (**264**—11–13). **Franconia:** Wis.

C. wichitaensis Resser (**264**—14, 15). **Ft. Sill:** Okla.

CONASPIS Hall 1863

(**Conocephalites perseus*). Cephalon rectangular, genal spines narrow; facial sutures diverge slightly in front of eyes and are intramarginal to center; brim narrow; rim thickened; posterior glabellar furrows almost confluent. **U. Camb.** (Mississippi Valley).

***C. perseus** (Hall) (**263**—27). **Franconia:** U. Mississippi Valley.

COOSELLA Lochman 1936

(**C. prolifica*). Differs from *Coosia* in having a broader cranidium with a rim as well as in pronounced bilobed appearance of pygidial marginal border; characterized by pinching in of brim so that front of cephalon is narrowed. **U. Camb.** (N. America).

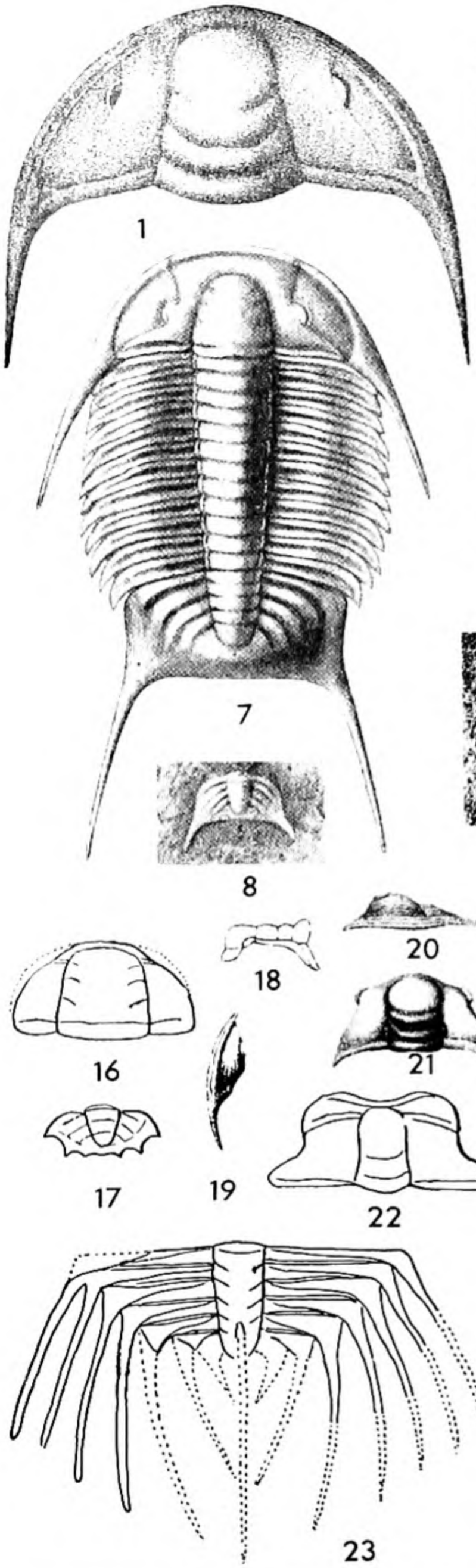
***C. prolifica** Lochman (**264**—16–21). **Bonneterre:** Mo.

C. curticei Resser (**264**—28). **Nolichucky:** Ala.

PLATE 261

[Figures are x1 and from Ulrich and Resser [Mil Pub Mus, B 12] unless otherwise indicated.]

1–4. Dikelocephalus spp. **1, 2. D. norwalkensis.** Incomplete cranidium and pygidium. **3, 4. D. gracilis.** Cranidium and pygidium. **5, 6. Tellerina crassimarginata.** An entire dorsal shield; holotype cranidium. **7, 8. Dikelocephalus minnesotensis.** Cranidium and pygidium, somewhat restored; both originally figured by Owen. **9–11. Prosaukia misa.** Free cheek; pygidium; large cranidium. **12. Dikelocephalus owenl.** A large incomplete cephalon. **13–16. Calvinella** spp. **13, 14. C. spiniger.** Pygidium and cranidium. **15, 16. C. ozarkensis** [Mo G S 24; photographs furnished by J. Bridge]. Side and dorsal views of an incomplete cranidium.



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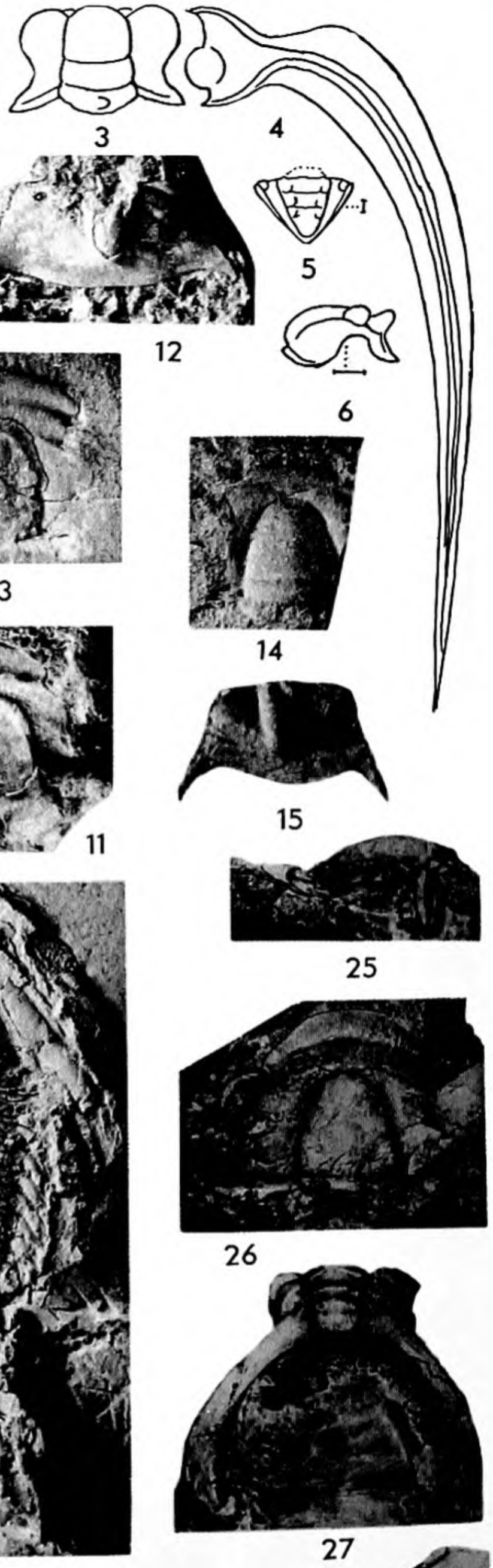

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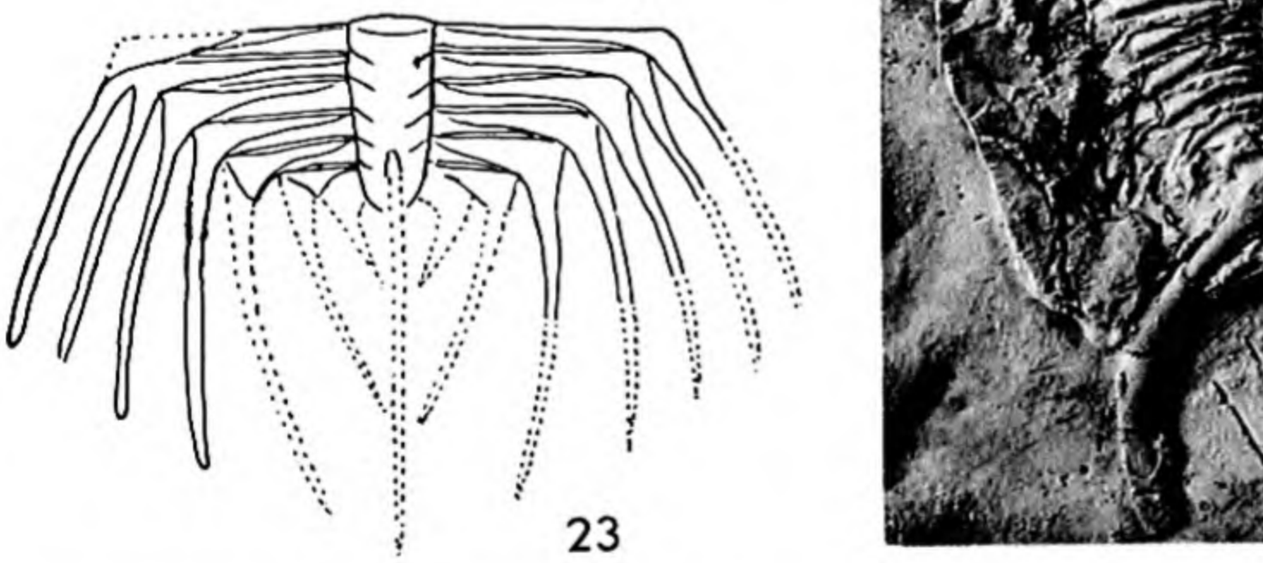

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COOSIA Walcott 1911

(**C. superba*). Cephalon semicircular in outline, moderately convex; brim wide, convex, without rim; glabella convex, with slight traces of lateral furrows; fixed cheeks narrow, about a fourth or less of glabellar width, merging posteriorly into large, subtriangular posterolateral limbs; doublure wide and stout under both shields. **U. Camb.** (N. America).

***C. superba** Walcott (**264**—25). **Nolichucky:** Ala.

C. robusta Walcott (**264**—26). **Nolichucky:** Tenn.

C. connata (Walcott) (**264**—23, 24). **U. Camb.:** Wis. (Dresbach); Mont. (Pilgrim).

CREPICEPHALUS Owen 1852

(**Dikelocephalus? iowensis*). Characterized by elongate tapering glabella with two or three pairs of short furrows; eye lines present; free cheeks have strong genal spines; thorax with 12 to 14 segments; pygidium with two prominent divergent spines. **U. Camb.** (N. America).

C. explicatus Resser (**262**—12). **Nolichucky:** Tenn.

***C. iowensis** (Owen) (**262**—7, 8). **Dresbach:** U. Mississippi Valley region.

C. buttsi Resser (**262**—13–15). **U. Camb.:** Va. (Nolichucky), Mont. (Pilgrim).

CTENOPYGE Linnarsson 1880

(**Olenus* (*Sphaerophthalmus*) *pecten* Salter). Cephalon like *Sphaerophthalmus*, but axial lobe of body narrower proportionally; posterior portion of fixed cheeks broader; glabella reaches anterior margin; facial suture a regular sigmoid curve; pygidium large, its divisions ending in long spines. **U. Camb., Ord.** (Atlantic Province).

***C. pecten** (Salter) (**262**—22, 23). Glabella parallel sided and reaching frontal margin; divisions of pygidial axis prominent only on its sides. **Bretonian:** N. B.

C. acadica Matthew (**263**—5–7). Spine of free cheek opposite median portion of cephalon and strongly curved; rectangular hypostoma, wholly bordered by a marginal fold, consists of an oval anterior portion and a lower crescentic posterior portion. **Narrows:** N. B.

DIKELOCEPHALUS Owen 1852

(**D. minnesotensis*). Cephalon broad with a wide concave brim bounded by an anterior rim; genal spines present; glabella quadrangular in outline; posterior pair of glabellar furrows turned backward, strongly defined and confluent across middle of glabella; second pair short; thoracic segments probably 12; pygidium large, wide, with convex axial lobe, anterior half or more of which has four transverse rings; pleural ribs number 9 or 10 and may be subequal; posterior border with flat spine at each lateral angle; widespread but uncommon. **U. Camb.** (central and western N. America — Wis., Minn., Ia., N. Mex., Nev.; Alta.).

***D. minnesotensis** Owen (**261**—7, 8). Cranidium large, relatively flat with wide, gently concave and slightly upturned brim. **Trempealeau:** Wis., Minn.

D. gracilis Ulrich and Resser (**261**—3, 4). **Trempealeau:** Wis., Minn., Ia.

D. norwalkensis Ulrich and Resser (**261**—1, 2). **Trempealeau:** U. Mississippi Valley.

D. oweni Ulrich and Resser (**261**—12). **Trempealeau:** U. Mississippi Valley.

DOKIMOCEPHALUS Walcott 1924

(**Ptychoparia pernasuta*). Characterized by long, pointed frontal extension of rim, large convex glabella with deep furrows, deep dorsal furrows and elaborate surface ornamentation. **U. Camb.** (central and western U. S. A.).

D. gregori Walcott (**264**—38, 39). **U. Camb.:** Mo.

DRESBACHIA Walcott 1916

(**D. amata*). Glabella subtriangular in outline, marked by three pairs of oblique, short, deep lateral furrows; fixed cheeks extremely wide and long. **U. Camb.** (N. America).

***D. amata** Walcott (**264**—22). **Dresbach:** U. Mississippi Valley.

DRUMASPIS Resser 1942

(**D. walcotti*). Trilobites of *Chariocephalus–Irvingella* group; differ in restriction of eye and increase of fixed cheek to more than palpebral lobe; glabella same as for group; eyes reduced about a third to equal from one-half to two-thirds the glabellar length; anterior end of eye joins dorsal furrow, rear end removed a considerable distance by development of more normal fixed cheek. **U. Camb.** (central and western N. America).

***D. walcotti** Resser (**264**—33). **St. Charles:** Wasatch Mts.

PLATE 262

[Figures are x1 unless otherwise indicated; photographs furnished by Resser are indicated by CER.]

1, 2. Ptychaspis spp. **1. P. miniscaensis** [N Y St Cab 16]. Cephalon restored. **2. P. striata** [CER]. **3–6. Sphaeropthalmus fletcheri** [N H Soc N B, B 19 (4)]. Cranidium, free cheek, pygidium, and side view of cranidium; all much enlarged. **7, 8. Crepicephalus iowensis** [SMC 64 (3)]. Restored figure of entire dorsal shield; small, nearly entire pygidium. **9, 10. Osceolia osceola** [CER]. Cranidium and impression of pygidium. **11. Tricrepicephalus tripunctatus** [CER]. Cranidium showing three prominent pits (original type). **12–15. Crepicephalus** spp. **12. C. explicatus** (x1.5) [CER]. Nearly complete pygidium. **13–15. C. buttsi** (x1.5) [GSA, SP 15; CER]. Cranidia (x1.5); holotype pygidium. **16, 17. Peltura scarabaides** [NAIF; after Matthew]. Outlines of cephalon and pygidium. **18–21. Ptychaspis granulosa** [N Y St Cab 16]. Profile of cephalon; dorsal and side views of a free cheek; a large cephalon. **22, 23. Ctenopyge pecten** (x2.5) [N H Soc N B, B 19 (4)]. Outlines of cranidium and pygidium. **24–28. Tricrepicephalus** spp. **24. T. cedarensis** [GSA, SP 15; CER]. Holotype (x1.5). **25–28. T. texanus** [JP 10]. Side and dorsal views of neoholotype; dorsal and side views of pygidium. **29–31. Briscoia sinclairensis** [SMC 75 (3)]. Dorsal and side views of a large pygidium; cranidium.

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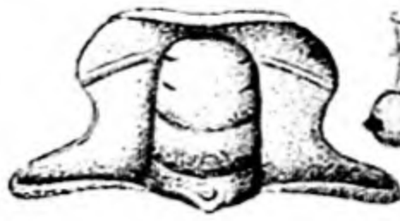
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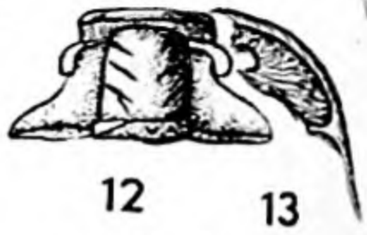
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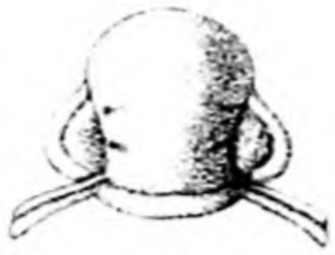
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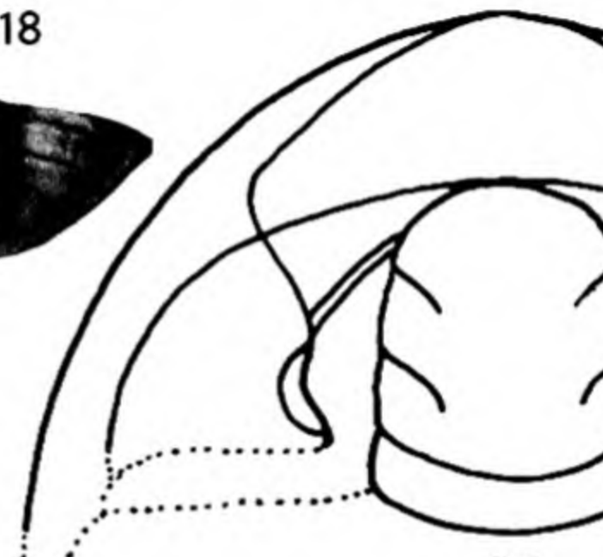
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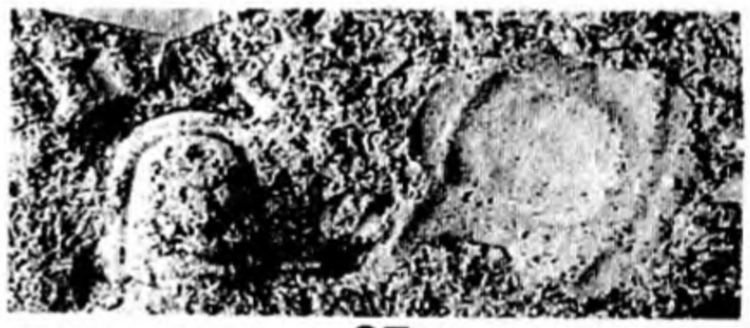
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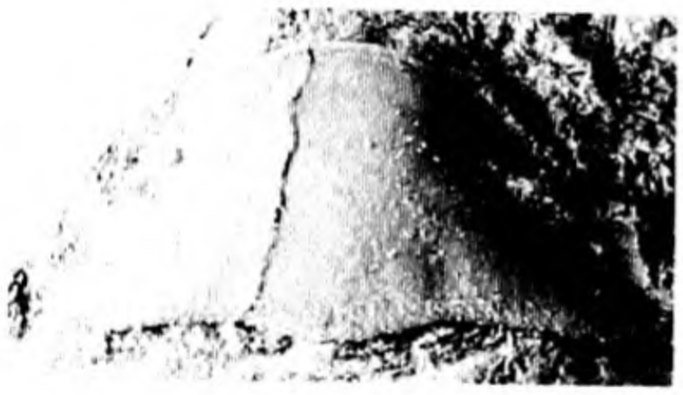
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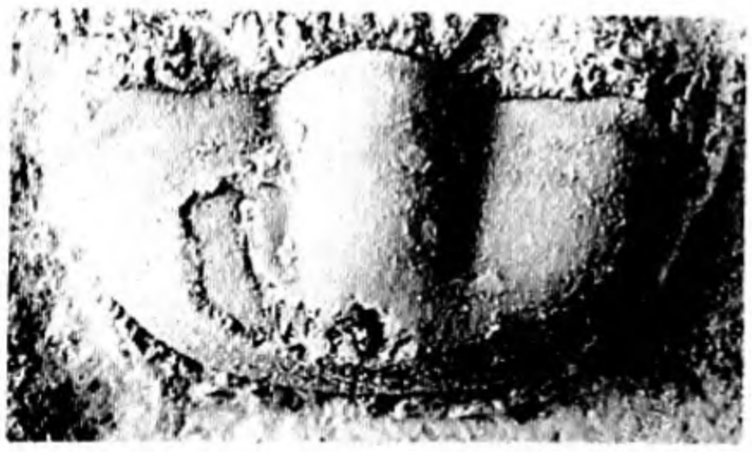
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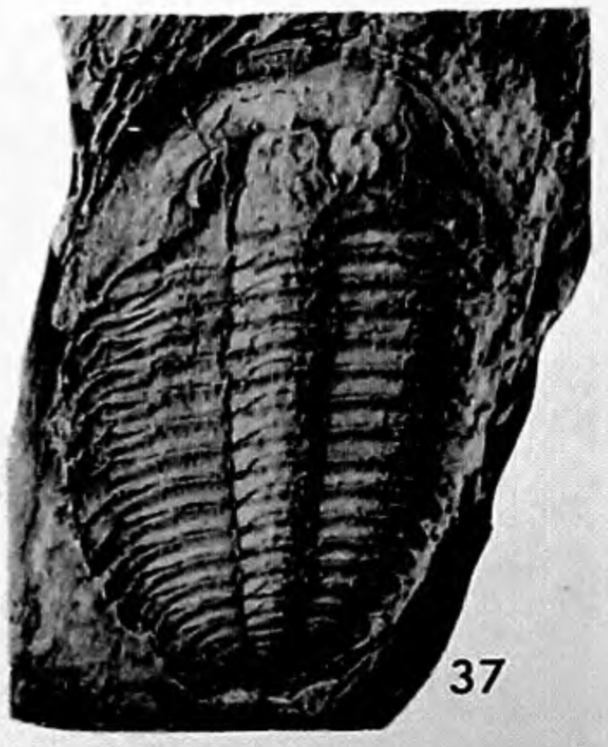
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D. idahoensis Resser (**264**—31, 32). **St. Charles:** Idaho.

DUNDERBURGIA Walcott 1924

(**Crepicephalus* (*Loganellus*) *nitidus* Hall and Whitfield). Characterized by short glabella without furrows; eye lines strong; narrow, thickened rim; pygidium semicircular with long tapering axial lobe which reaches broad border. **U. Camb.** (Cordilleran region).

***D. nitida** (H and W) (**264**—29, 30). **Dunderburg:** Nev.

ELVINIA Walcott 1924

(**Dikelocephalus roemeri* Shumard). Glabella with two pairs of glabellar furrows; strong eye lines, wide posterolateral limbs; wide brim and thickened rim; many species and widespread. **U. Camb.** (Pa. (Ore Hill), Wis. (Franconia), Mo. (Davis), S. Dak. (Deadwood), Okla. (Honey Creek), Tex. (Wilberns), Utah, Nev. (Dunderburg; not Secret Canyon as previously published [personal correspondence from J. Bridge, 1942])).

***E. roemeri** (Shumard) (**264**—34–37). **U. Camb.:** Tex.

E. shumardi Resser (**264**—41, 42). **Wilberns:** Tex.

E matheri (Walcott) (**264**—40). **Potsdam:** N. Y.

ENTOMASPIS Ulrich 1930

(**E. radiata*). Similar to *Eoharpes*, but with marginal facial suture cutting across the genal angles as in the trinuclids; surface of cephalon with numerous radial lines. **U. Camb.** (Mo.), **L. Ord.** (Vt.).

***E. radiatus** Ulrich (**265**—1–3). **U. Camb.:** Mo. (Eminence).

EUPTYCHASPIS Ulrich 1930

(**E. typicalis*). Differs from *Ptychaspis* in having wider cranidium, smooth fixed cheeks as wide as glabella, widening of cranidium, and lateral extension of ends of convexly bowed and abruptly deflected anterior border; eyes small, opposite middle lobe of glabella; a strong spine extends backward as far as length of glabella; glabella prominent and crossed by two deep furrows. **U. Camb.** (widespread in central and western N. America).

***E. typicalis** Ulrich (**264**—27). **U. Camb.:** Mo. (Eminence).

EUREKIA Walcott 1924

(**E. granulosa*). Cephalon short and wide with broad free cheeks bearing spines; glabella short and wide with two pairs of incomplete furrows, reaches brim, which is upturned and curved back to meet it; surface generally tuberculate; pygidium with numerous spines. **U. Camb.** (central and western N. America).

***E. granulosa** Walcott (**265**—13, 14). **Dunderburg:** Nev.

E. eos (Hall) (**265**—4–6). **Trempealeau:** Wis.

GENEVIEVELLA Lochman 1936

(**G. neunia*). Glabella large, tumid, tapering anteriorly; glabellar furrows short and straight; occipital furrow broad and shallow; fixed cheeks one-half glabellar width, strongly convex; intramarginal furrows shallow; frontal border of medium width, convex; pygidium with long slender axis; pleural platforms moderately convex; border wide, often flaring at posterior angles; furrows extend to margin. **U. Camb.** (Mo., Mont.).

***G. neunia** Lochman (**265**—10–12). **Bonneterre:** Mo.

HOUSIA Walcott 1916

(**Dolichometopus* (*Housia*) *varro*). Cranidium long, expanded in front, and with concave and flaring brim; wide posterolateral limbs; eyes small; free cheeks with wide border, with or without genal spines; a thoracic segment usually remains attached to the pygidium. **U. Camb.** (central and western N. America).

***H. varro** (Walcott) (**265**—9). **Orr:** Utah.

H. canadensis (Walcott) (**265**—7, 8). **"Goodsir":** B. C.

IDAHOIA Walcott 1924

(**I. serapio*). Cranidium long, with short glabella, long neck spine, strong eye lines, wide preglabellar area with wide flat brim, and wide posterolateral limbs; free cheeks with long spines and wide doublure; pygidium almost smooth. **U. Camb.** (N. America).

***I. serapio** Walcott (**265**—20, 21). **Ovid:** Idaho.

I. hamulus (Owen) (**265**—18, 19). **Franconia:** U. Mississippi Valley.

I. wisconsensis (Owen) (**265**—17). **U. Camb.:** Wis., Minn.

PLATE 263

[Figures are x1 unless otherwise indicated; photographs for figures 3, 4, 17, 19, 20, 24, 25, and 27–37 furnished by C. E. Resser; 21–23 by C. L. Lochman.]

1, 2. Kingstonia walcotti [GSA, SP 15]. Two cranidia (x3) and a pygidium (x4). **3, 4. Blountia mimula** (x3) [GSA, SP 15]. Holotype specimen; a good pygidium. **5–7. Ctenopyge acadica** [NAIF; after Matthew]. Hypostoma, cranidium, and free cheek. **8. Acheilus marcoui** (x4) [Vt G S 14]. **9–11. Acheilops dilatus** [Mo G S 24]. Reconstructed cranidium (x3) and another cranidium (x1, x2). **12–14. Parabolina spinulosa** [R Soc Can, Tr 9]. Cranidium, free cheek, and pygidium. **15–20. Arapahoia** spp. **15, 16. A. ransomei** [GSA, B 47]. Cranidium and pygidium. **17, 18. A. typa.** Cranidium and pygidium on a slab; the holotype [JP 10]. **19, 20. A. prolixa** (x1.5). Pygidium and cranidium. **21–23. Brassicephalus pulchellus** (x3) [JP 14; CL]. Front, dorsal, and side views of holotype. **24–26. Burnetia** spp. **24. B. extensa. 25, 26. B. urania.** An incomplete cranidium; outline of cephalon [SMC 75 (2)]. **27. Conaspis perseus.** An incomplete cranidium and impression of a species of *Wilbernia*. **28–30. Kingstonia apion** (x6). Cranidium; two pygidia, the lower one almost completely exfoliated. **31. Aphelaspis walcotti.** Cranidia (x1.5). **32–34. Bynumia** spp. **32, 33. B. robsonensis.** Pygidium (x3.5) and cranidium (x4). **34. B. eumus** [SMC 75 (3); CER]. Type cranidium (x3). **35–37. Aphelaspis** spp. **35, 36. A. depressus.** Two cranidia and a pygidium. **37. A. hamblenensis** (x1.5). An almost complete specimen.

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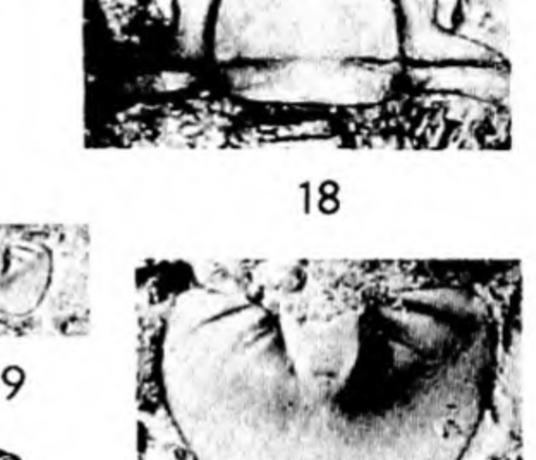

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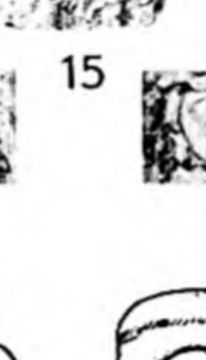

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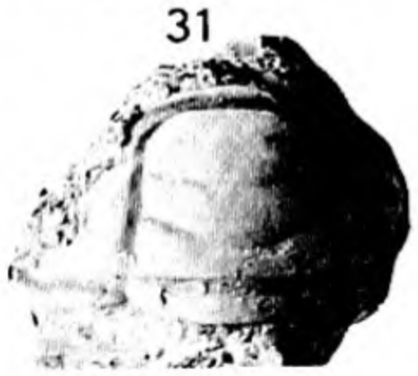

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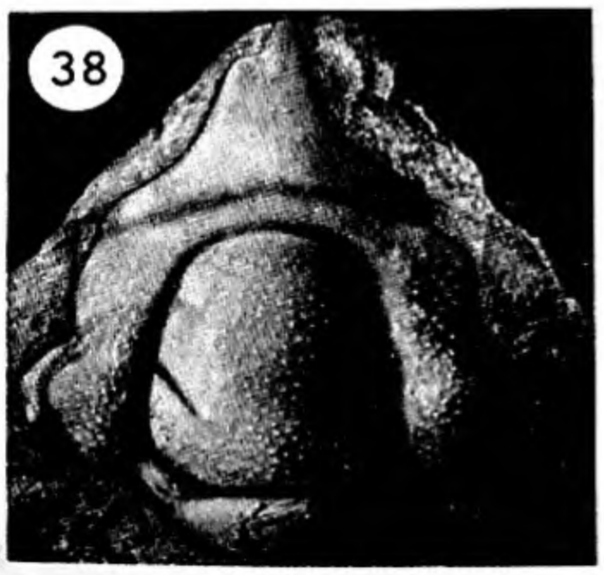

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IDDINGSIA Walcott 1924

(**Ptychoparia similis*). Cranidium distinguished by its sloping border, almost equally divided by the anterior furrow into convex brim and rim; strongly developed glabella and narrow fixed cheeks; differs from *Dunderburgia* and *Modocia*, in equal width of its brim and rim. **U. Camb.** (western N. America).

I. similis (Walcott) (**265**—15, 16). **U. Camb.:** Nev.

ILLAENURUS Hall 1863

(**I. quadratus*). Cranidium smooth and subquadrate with small eyes and no brim; posterolateral limbs narrow and straplike; free cheeks very wide, without spines; many species. **U. Camb.** (central and western N. America).

***I. quadratus** Hall (**260**—16–19). **Trempealeau:** U. Mississippi Valley.

I. albertensis Resser (**260**—15). **Lyell:** Canadian Rockies.

IRVINGELLA Ulrich and Resser 1924

(**I. major*). Cranidium short with blunt glabella almost reaching front of shield; posterior glabellar furrows confluent, anterior pair faint; very short posterolateral limbs; long eyes, brim a simple bar; many species. **U. Camb.** (central and western U. S. A.).

***I. major** U and R (**265**—25). **Franconia:** Wis., Okla., Tex., Wyo.

I. media Resser (**265**—26, 27). **Wilberns:** Tex.

KINGSTONIA Walcott 1924

(**K. apion*). Cranidium truncated triangular; glabella generally defined only at rear except on exfoliated specimens; no neck ring; wide posterolateral limbs; small eyes; narrow rim; pygidium with dorsal furrow defining axial lobe but otherwise smooth; many species. **U. Camb.** (N. America).

***K. apion** Walcott (**263**—28–30). **Dresbach:** S. Appalachians (Nolichucky), Tenn. (Maryville), Mo. (Bonneterre).

K. walcotti Resser (**263**—1, 2). **U. Camb.:** Tenn. (Nolichucky), Mont. (Pilgrim).

LONCHOCEPHALUS Owen 1852

(**L. chippewaensis*). Characterized by a short convex glabella, and narrow brim and rim; median spine on occipital ring; thoracic segments six or seven; pygidium with little or no border and with four segments on axial lobe. **U. Camb.** (N. America).

***L. chippewaensis** Owen (**265**—30). **Dresbach** (Crepicephalus zone): U. Mississippi Valley.

L. minor (Shumard) (**265**—22–24). Same as preceding.

MALADIA Walcott 1924

(**M. americana*). Cranidium subquadrate with wide and smooth glabella, thickened rim, and short posterolateral limbs; free cheeks without spines; pygidium with short axis and notched edge. **U. Camb.** (Cordilleran region).

***M. americana** Walcott (**265**—28, 29). **St. Charles:** Wasatch Mts.

MARYVILLIA Walcott 1916

(**M. arion*). Glabella large, preglabellar area as wide as rim and separated from thickened rim by deep anterior furrow; eyes small; pygidium like *Coosia*, but more convex and without wide flat border. **U. Camb.** (N. America).

***M. arion** Walcott (**265**—31, 32). **Nolichucky:** Tenn.

MENOMONIA Walcott 1916

(= MILLARDIA Walcott 1916)

(**Conocephalites calymenoides* Whitfield). General form elongate, lance-shaped, with cephalon at broad end; strongly convex; axial and pleural lobes strongly outlined; thorax with 42 segments. **U. Camb.** (N. America).

***M. calymenoides** (Whitfield) (**265**—36). **U. Camb.:** U. Mississippi Valley (Dresbach), S. Dak. (Deadwood).

M. buttsi Resser (**265**—35). **Nolichucky:** Ala.

M. avitas (Walcott) (**265**—33, 34). **U. Camb.:** Newf. (Petit Jardin); Pa. (Warrior), Mo. (Bonneterre), Tex. (Cap Mt.).

M. semele Walcott (**265**—37, 38). **Weeks:** Utah.

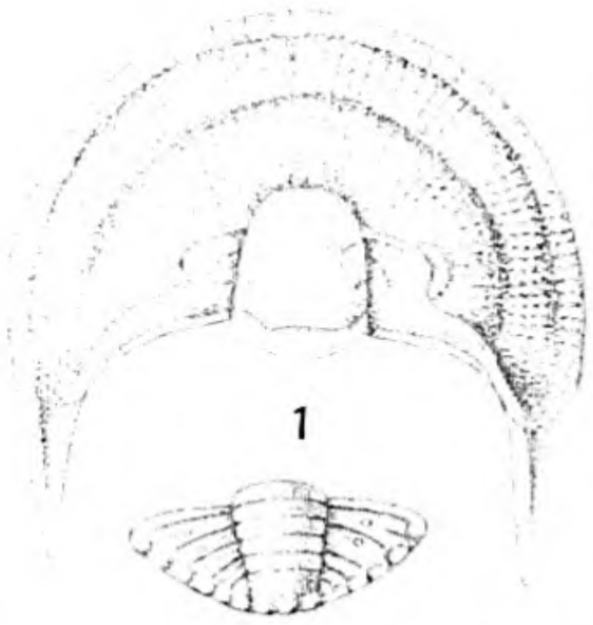
METEORASPIS Resser 1935

(**Ptychoparia? metra* Walcott). Cranidium but little larger than glabella; dorsal furrows well defined; occipital furrow deep; brim about a third as wide as glabella, heavy, thickened; two pits in

PLATE 264

[Figures are x1 unless otherwise indicated; photographs furnished by Resser are indicated by CER.]

1–10. Çedaria spp. 1, 2. C. minor (x3) [SMC 64 (5)]. Dorsal shield; interior of a dorsal shield showing doublure and position of hypostoma. **3–7. C. prolifica.** Nearly complete specimen, cephalon, and pygidium (x1.5) [SMC 75 (3)]; two well preserved but crushed cephalons (x1.5) [GSA, SP 15; CER]. **8–10. C. woosteri** [Wis G S 4]. Cephalon, pygidium, and outline side view of cephalon (x1.5). **11–15. Chariocephalus spp.** [CER]. **11–13. C. whitfieldi.** Free cheek, cranidium, and pygidium. **14, 15. C. wichitaensis** (x1.5). Cranidium and pygidium. **16–21. Coosella prolifica** [JP 10]. Holotype cranidium, dorsal view (x1), side and dorsal views (x4); pygidium (x1, x4); free cheek (x4). **22. Dresbachia amata** (x5) [CER]. **23–25. Coosia spp.** [23, 24: USNM, Pr 13. 25, 26: GSA, SP 15; CER]. **23, 24. C. connata.** Profile and dorsal views of cranidium. **25. C. superba.** Incomplete dorsal shield. **26. C. robusta.** Incomplete cranidium. **27. Euptychaspis typicalis** (x6) [CER]. **28. Coosella curticei** [CER]. Under side of a dorsal shield. **29, 30. Dunderburgia nitida** (x1.5) [CER]. Cranidium and pygidium. **31–33. Drumaspis spp. 31, 32. D. idahoensis** [CER]. Front and dorsal views of cranidium (x2). **33. D. walcotti** [CER]. Well preserved cranidium (x1.5). **34–37. Elvinia roemeri** [SMC 75 (3)]. Side and dorsal views of a typical cranidium; side and dorsal views of pygidium. **38, 39. Dokimocephalus gregori** [SMC 75 (3)]. Dorsal and side views of cranidium. **40–42. Elvinia spp.** [CER]. **40. E. matheri. 41, 42. E. shumardi.** Cranidium and pygidium.



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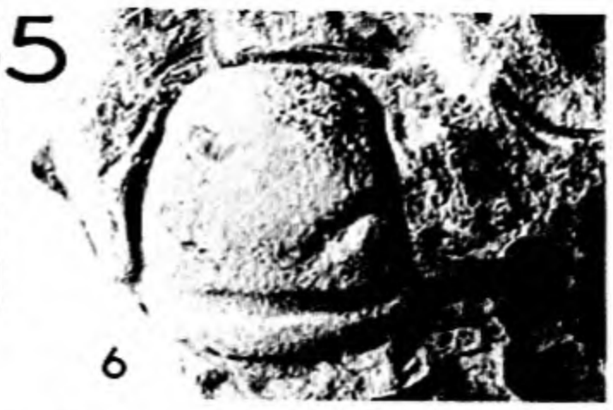

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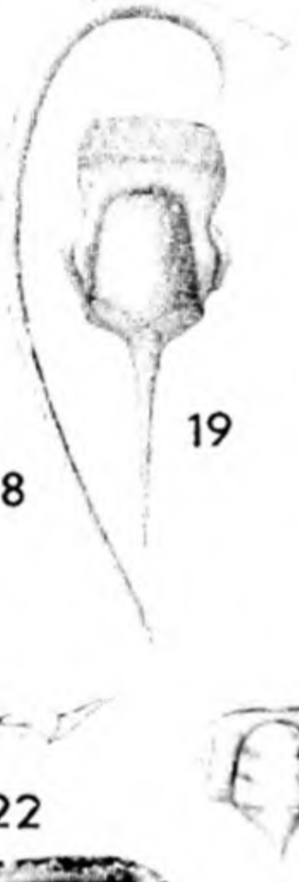

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transverse furrow; eyes rather large. **U. Camb.** (central and western N. America).

***M. metra** (Walcott) (**265**—42). **Cap Mt.:** Tex.

MODOCIA Walcott 1924

(**Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden). Glabella bluntly conical, furrows poorly developed; fixed cheeks wide; rim thickened; eyes small; posterolateral limb short. **U. Camb.** (central and western N. America).

***M. oweni** (M and H) (**265**—39–41). **U. Camb.:** S. Dak. (Deadwood), Mont. (Pilgrim), Wyo.

MONOCHEILUS Resser 1937

(**Conocephalites anatinus* Hall). Fixed cheeks very narrow; no rim; posterolateral limbs very wide. **U. Camb.** (central and western N. America).

***M. anatinum** (Hall) (**266**—1–3). **Franconia:** U. Mississippi Valley.

NORWOODELLA Resser 1938

(**Norwoodia saffordi* Walcott). Central part of cranidium greatly reduced; posterolateral limbs greatly extended and bearing long spine; glabella small with long neck spine; preglabellar area and rim wide. **U. Camb.** (N. America).

***N. saffordi** (Walcott) (**266**—4). **Dresbach:** S. Appalachians.

N. halli Resser (**266**—5, 6). **U. Camb.:** Tenn. (Nolichucky), Mo. (Bonneterre).

NORWOODIA Walcott 1916

(**N. gracilis*). General form of cephalon a broad ellipse, moderately convex, with pleural lobes more or less flattened; other features shown in illustrations of genotype. **U. Camb.** (eastern and central U. S. A.).

***N. gracilis** Walcott (**266**—16). **U. Camb.:** Tenn. (Nolichucky), Ga. and Ala. (Conasauga).

ORYGMASPIS Resser 1937

(**Ptychoparia llanoensis* Walcott). Cranidium long, narrow and flat; glabella two thirds length of head, slightly tapered; dorsal furrows shallow; brim flat, on exfoliated specimens rim margined in rear by row of tubercles; fixed cheeks narrow; surface smooth except for marginal striations; exfoliated specimens sparsely granulose. **U. Camb.** (central and western N. America).

O. eryon (Hall) (**266**—33, 34). **Franconia:** Wis.

OSCEOLIA Walcott 1914

(**Dikelocephalus osceola* Hall). Cephalon essentially same as in *Dikelocephalus* and *Briscoia;* differs from these in its wider pygidium, which has large lateral spines, three instead of four or five axial rings, and obsolescent pleural furrows. **U. Camb.** (central and western N. America).

***O. osceola** (Hall) (**262**—9, 10). Anterior to glabella is a broad groove with an abruptly elevated narrow border; occipital and first glabellar furrows confluent, second pair barely indicated. **Trempealeau:** Wis.

PARABOLINA Salter 1849

(**Entomostracites spinulosus* Wahlenberg). Glabella long, rather truncate at front; eyes near anterior angles of glabella; 12 thoracic segments; pygidium with several spines on each side. **U. Camb.** (Atlantic Province; Europe), **Ord.** (Argentina).

***P. spinulosa** (Wahlenberg) (**263**—12–14). **Narrows:** N. B.

PELTURA Milne-Edwards 1840

(**Entomostracites scarabaeoides* Wahlenberg). Cephalon semicircular; glabella wide and long, extending nearly to frontal margin; eyes small and far forward; genal margins of cheeks rounded; axis wider than pleura; pygidium shield-shaped, well developed, with notched margin. **U. Camb.** (eastern N. America; northern Europe).

***P. scarabaeoides** (Wahlenberg) (**262**—16, 17; **276**—24). **U. Camb.:** Newf.; N. B.; Europe.

PLATYCOLPUS Raymond 1913

(**Bathyurus capax* Billings). Glabella large, long, without furrows, reaches rim; eyes long; pygidium smooth except for well defined axial lobe; many species. **U. Camb.** (N. America).

***P. capax** (Billings) (**260**—24, 25). **Levis:** Que.

P. whitfieldi Resser (**260**—20, 21). **Trempealeau:** Wis.

P. sinclairensis Resser (**260**—22, 23). **Sabine:** B. C.

PLATE 265

[Figures are x1 unless otherwise indicated; photographs furnished by Resser are indicated by CER.]

1–3. Entomaspis radiatus (x5) [Mo G S 24; drawings furnished by J. Bridge]. **4–6. Eurekia eos** (x1.5) [CER]. Cranidia, variously lighted. **7–9. Housia** spp. **7, 8. H. canadensis** [CER]. Cranidium, and a fairly well preserved dorsal shield. **9. H. varro** [SMC 75 (3)]. **10–12. Genevievella neunia** (x4) [JP 10]. Side and dorsal views of a cranidium; pygidium. **13, 14. Eurekia granulosa** [SMC 75 (3)]. Cranidium and pygidium. **15, 16. Iddingsia similis** [SMC 75 (3)]. Dorsal and side views of the type cranidium. **17–21. Idahoia** spp. **17. I. wisconsensis** [N Y St Cab 16]. Cranidium. **18, 19. I. hamulus** [N Y St Cab 16]. Spine and cranidium with spine. **20, 21. I. serapio.** Photograph (x1.5) [CER]; Walcott's figure of same specimen [SMC 75 (3)]. **22–24. Lonchocephalus minor** [SMC 64 (3)]. Side, outline, and dorsal views of a typical specimen. **25–27. Irvingella** spp. [CER]. **25. I. major** (x1.5). Slab with cranidia. **26, 27. I. media.** Two cranidia, the larger (x5). **28, 29. Maladia americana** [CER]. Cranidium and pygidium. **30. Lonchocephalus chippewaensis** [SMC 64 (3)]. An almost complete dorsal shield (x3). **31, 32. Maryvillia arion** [CER]. Cranidium and pygidium. **33–38. Menomonia** spp. **33, 34. M. avitas** (x5) [CER]. Cephalons showing variation in preservation. **35. M. buttsi** (x5) [CER]. Poorly preserved cephalon. **36. M. calymenoides** (x5) [CER]. **37, 38. M. semele** (x4) [SMC 64 (3)]. Incomplete dorsal shield with 23 thoracic segments; cephalon. **39–41. Modocia oweni** [SMC 75 (3)]. Type cranidium; dorsal and side views of a second cranidium. **42. Meteoraspis metra** (x3) [CER]. Incomplete cranidium.

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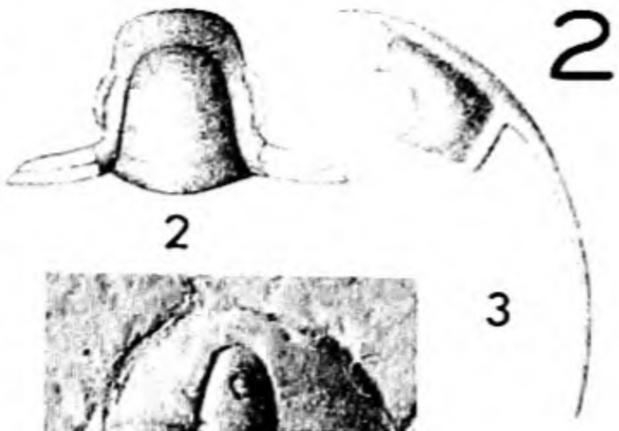
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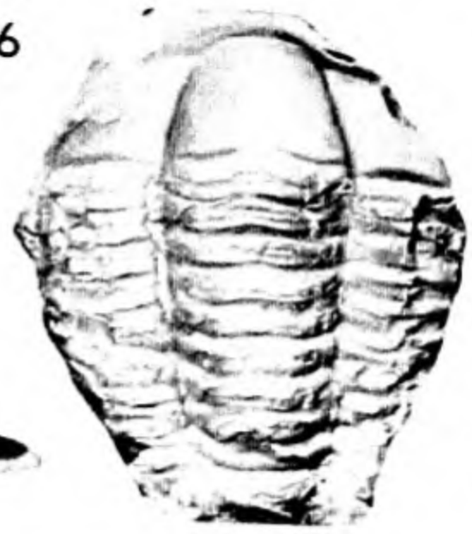
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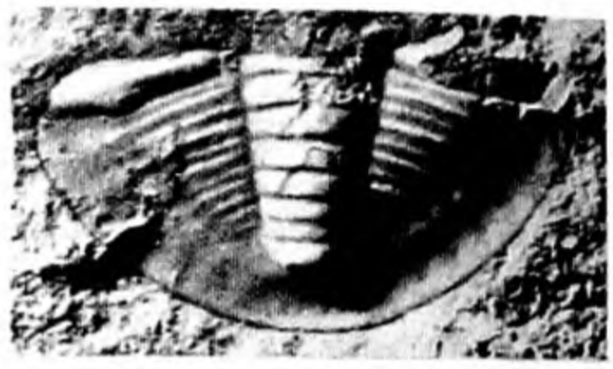
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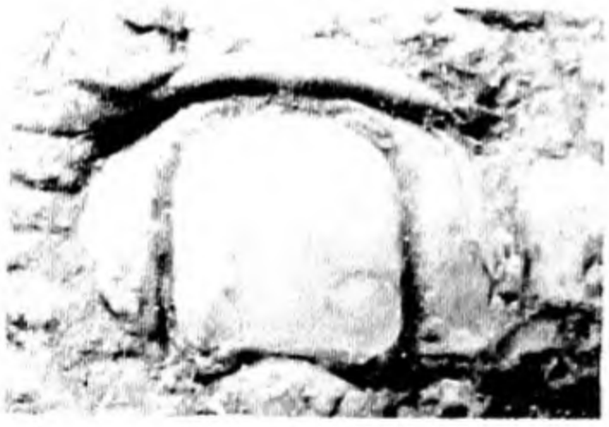
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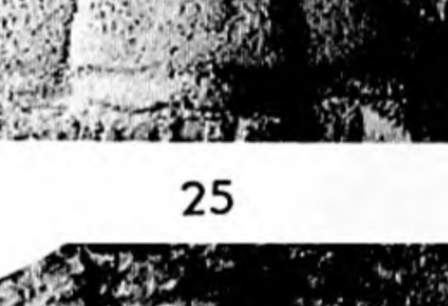
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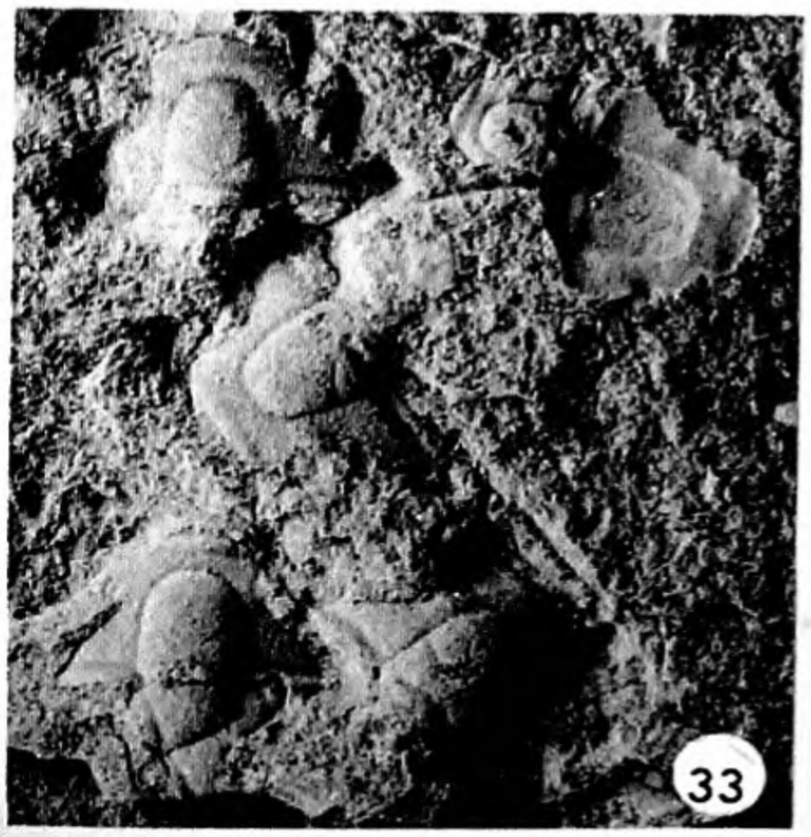
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PLETHOMETOPUS Ulrich 1930

(**Bathyurus armatus* Billings). Cranidium smooth, strongly convex; short posterolateral limbs and heavy, blunt neck spine. **U. Camb.** (Vt., Pa., Va., S. Appalachians (Copper Ridge), Wis. (Trempealeau), Mo., Tex. (L. Ellenburger)).

P. convexus (Whitfield) (**260**—6, 7). **U. Camb.:** Wis. (Trempealeau), Mo. (Eminence).

PLETHOPELTIS Raymond 1913, emend Ulrich 1930

(**Agraulos saratogensis* Walcott). Like *Plethometopus*, but glabella is clearly defined by circumglabellar furrow and neck spine is lacking. **U. Camb.** (N. Y.; and same distribution as *Plethometopus*).

***P. saratogensis** (Walcott) (**260**—1–3). **Hoyt:** N. Y.

P. buehleri Ulrich (**260**—4, 5). **Eminence:** Mo.

PROSAUKIA Ulrich and Resser 1933

(**Dikelocephalus misa* Hall). Cranidial dorsal furrows converging forward, frontal furrow rather wide and extending transversely across entire front of cranidium with its bottom usually distinctly though only very slightly convex longitudinally; glabella subrectangular, furrows variable in number, depth and direction; fixed cheeks narrow; eyes rather large; free cheeks as in *Saukia* and *Tellerina;* nuchal spine present or lacking; pygidium large, segmented, and with wide margin. **U. Camb.** (central and western N. America).

***P. misa** (Hall) (**261**—9–11). **Franconia:** U. Mississippi Valley.

PSEUDOLISANIA Kobayashi 1935

(**Lisania? breviloba* Walcott). Characterized by concave frontal border, anterior eyes, narrow occipital ring, large posterolateral limbs, and a large pygidium with a wide concave border and with each of its ribs separated into two by a furrow. **U. Camb.** (N. America).

***P. breviloba** (Walcott) (**266**—11–15). **Nolichucky:** Tenn.

PTEROCEPHALIA Roemer 1849

(**P. sanctisabae*). Glabella subtrigonal; circumglabellar furrow continuous; facial sutures widely separated anteriorly; thoracic segments smooth, obliquely truncated on each end; pygidium bordered by a wide thin plate which flares at posterior angles; axial lobe narrow, composed of 9 to 10 segments. **U. Camb.** (widespread in central and western N. America).

***P. sanctisabae** Roemer (**266**—35–37). **U. Camb.:** S. Dak. (Deadwood), Mo. (Davis), Arbuckle and Wichita Mts. (Honey Creek), Tex. (Wilberns), Nev. (Dunderburg).

PTYCHASPIS Hall 1863

(**Dikelocephalus granulosus* Owen, *partim*). Cephalon broad; fixed cheeks wide, depressed-convex; glabella generally parallel sided, convex, transversely lobed, prominent in front; eyes anterior to middle; frontal limb narrow; free cheeks nearly as wide as fixed cheeks, and with genal spines; many species. **U. Camb.** (widespread in central and western N. America).

P. miniscaensis (Owen) (**262**—1). Glabella very strongly arched and tapering; eyes small. **Franconia:** U. Mississippi Valley.

P. striata Whitfield (**262**—2). Occurs with preceding.

***P. granulosa** (Owen) (**262**—18–21). Occurs with preceding.

PTYCHOPLEURITES Kobayashi 1936

(= PTYCHOPLEURA Kobayashi 1936)

(**Ptychopleura brevifrons*). Glabella subquadrate with three pairs of furrows; occipital and dorsal furrows strong; frontal limb narrow; brim convex, elevated in middle; ocular ridge lacking; facial sutures diverge; surface finely granulose. **U. Camb.** (central and western N. America).

***P. brevifrons** (Kobayashi) (**266**—9, 10). **U. Camb.:** Western Canada.

SAUKIA Walcott 1914

(**S. lodensis* Walcott, not *Dikelocephalus lodensis* Whitfield). Test more or less strongly tuberculated with sides of glabella subparallel or slowly tapering forward; anterior rim of cranidium strongly convex, sharply set off from front of glabella by a deep narrow groove, and free cheeks with relatively narrow rim and slender genal spines; 12 thoracic

PLATE 266

[Figures are x1 unless otherwise indicated; photographs furnished by Resser are indicated by CER.]

1–3. Monocheilus anatinum (x1.5). 1. Two cranidia [CER]. 2, 3: Cranidium and free cheek [N Y St Cab 16]. **4–6. Norwoodella** spp. **4. N. saffordi** (x1.5) [CER]. **5, 6. N. halli** (x2) [GSA, SP 15]. Holotype cranidium, and a larger head. **7, 8. Triarthropsis nitida** [Mo G S 24]. Outline drawing of cranidium (x3); dorsal view of a cranidium (x2). **9, 10. Ptychopleurites brevifrons** (x4) [JP 10]. Holotype and a second cranidium. **11–15. Pseudolisania breviloba** [SMC 64 (5)]. Dorsal and side views of a broken cranidium with portions of nine thoracic segments attached; side view of a small cranidium (x4); side and dorsal views of a small pygidium enlarged (x4) to show segmentation of axis and pleural lobes. **16. Norwoodia gracilis** (x1.5) [CER]. A well preserved cephalon. **17. Taenicephalus shumardi** (x1.5) [CER]. Two fairly complete cranidia. **18, 19. Tostonia iole** (x1.5) [CER]. Cranidium and pygidium. **20–22. Wilbernia pero.** Photograph of type (x1.5) [CER]; Walcott's retouched figures of type cranidium, dorsal and side views [SMC 75 (3)]. **23. Terranovella obscura** [JP 12]. Holotype cranidium (x5). **24. Welleraspis jerseyensis** (x6) [photograph furnished by B. F. Howell]. **25–27. Uncaspis unca** (x1.5) [CER]. Cranidium; two pygidia showing differences in preservation. **28. Uncaspis micans** (x2) [CER]. A typical pygidium. **29–32. Talbotina** spp. (x5) [JP 12]. **29–31. T. degrasensis.** Dorsal and side views of holotype cranidium; pygidium. **32. T. solitaris. 33, 34. Orygmaspis eryon** [CER]. A slab with a number of cranidia; pygidium. **35–37. Pterocephalia sanctisabae** [USGS, PP 186]. Side and dorsal views of two large pygidia; exterior and interior of two cranidia.

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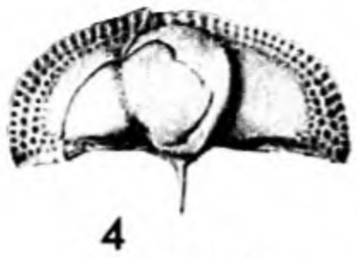

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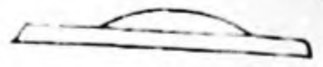

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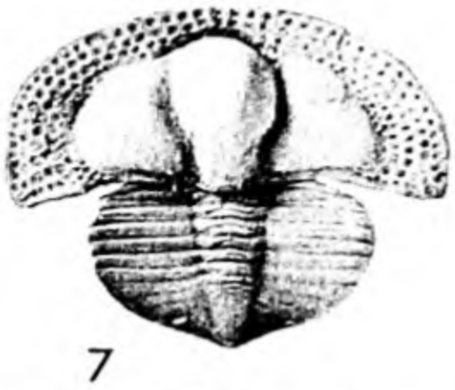

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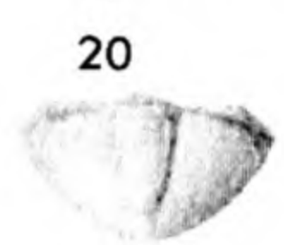

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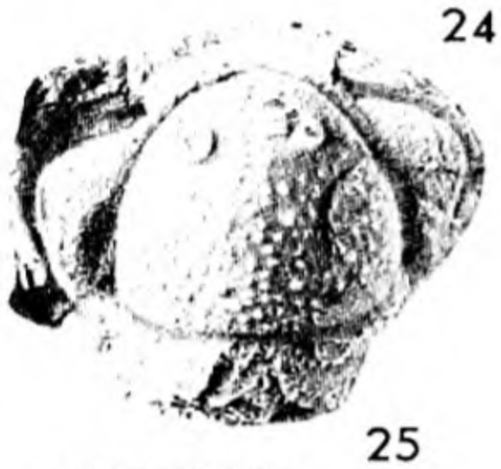

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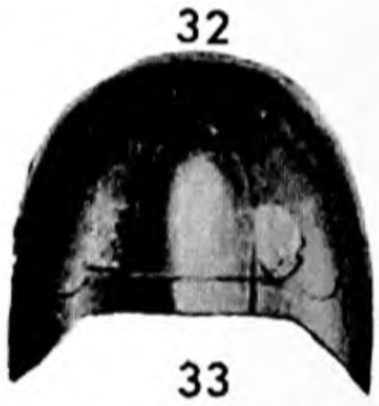

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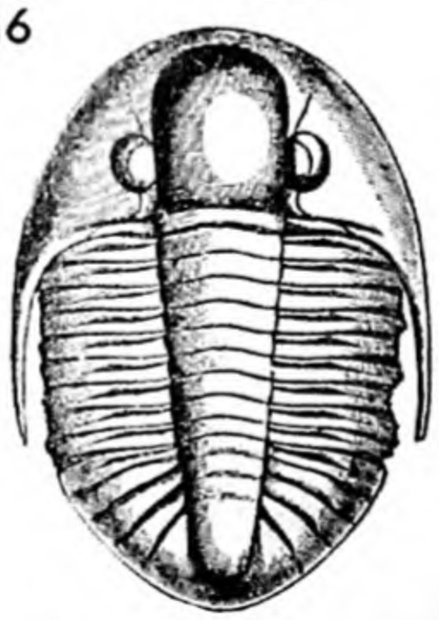

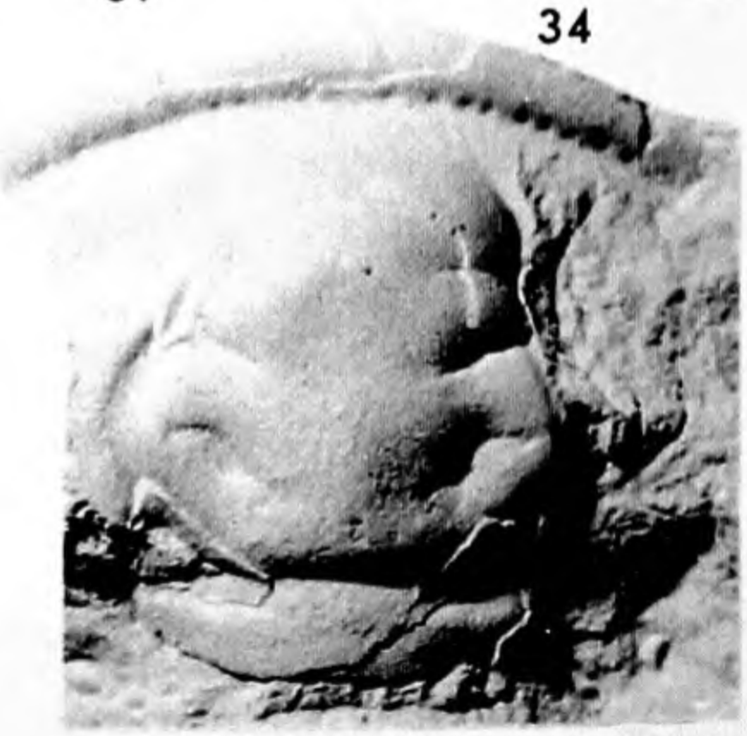

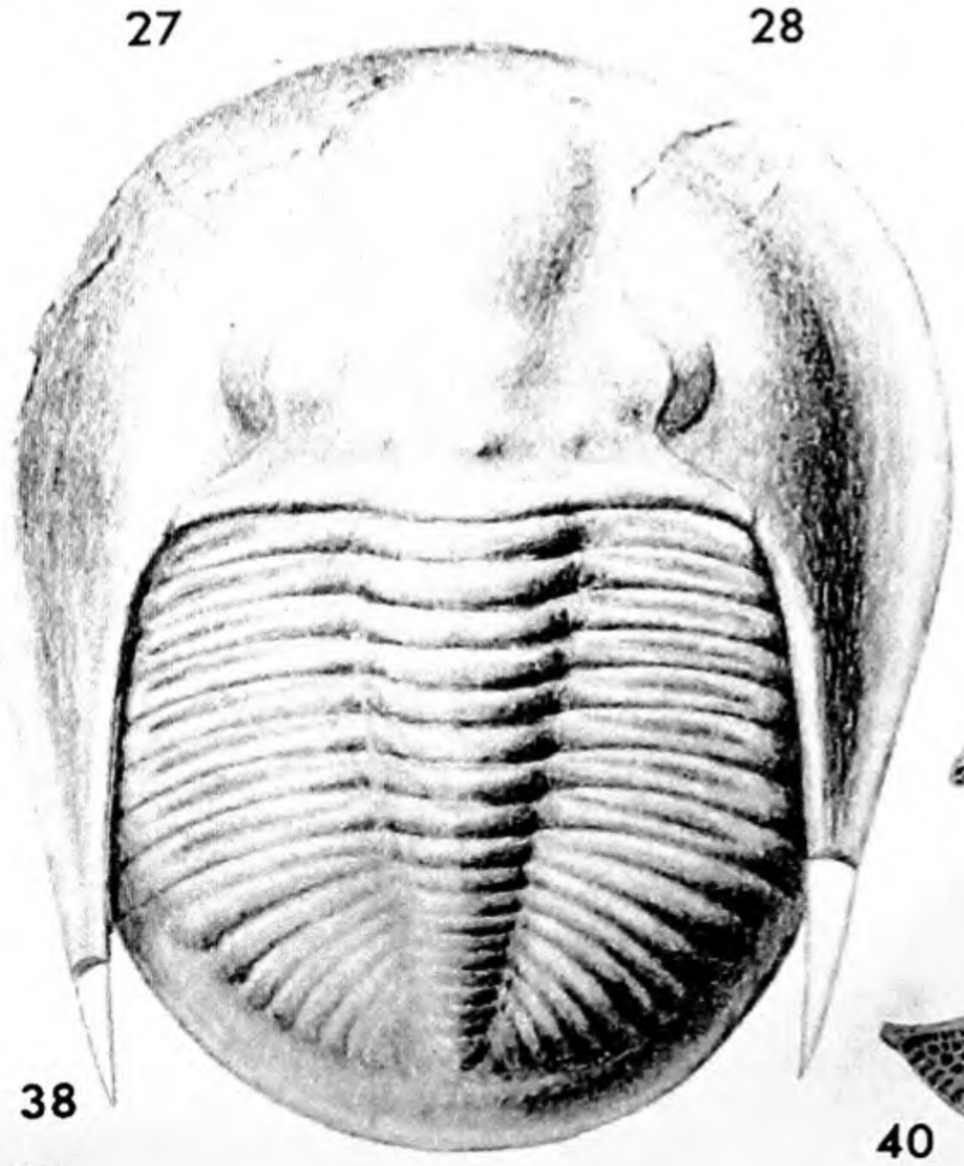

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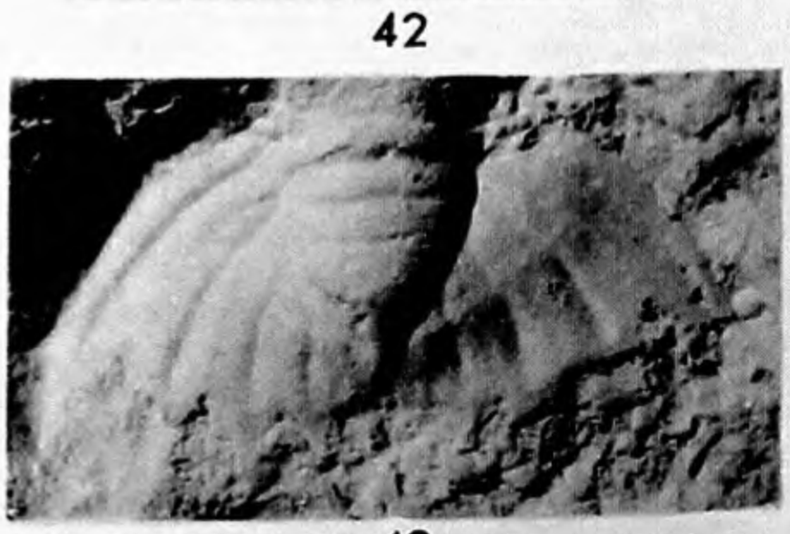

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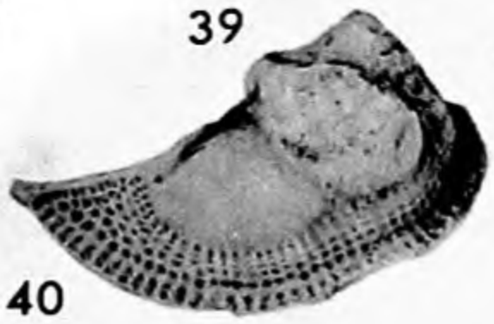

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segments; pygidium transversely subelliptical with rapidly tapering axial lobe with four or five complete rings; pleural ribs grooved and subequally divided, both dying out on the rather narrow, smooth, concave border. **U. Camb.** (N. America; Asia?).

***S. acuta** U and R (**260**—30). **Trempealeau:** U. Mississippi Valley.

SAUKIELLA Ulrich and Resser 1933

(**Saukiella typicalis* Ulrich and Resser = *Saukia pepinensis* [*pars*] Walcott, not *Dikelocephalus pepinensis* Owen). Carapace smooth, moderately convex, with cephalic marginal furrow wide in front of glabella; glabella and cranidium as a whole elongate; occipital and first pair of glabellar furrows continuous; remainder of glabella either unfurrowed or with second pair, and rarely also the third, obscure; fixed cheeks narrow, eyes large, situated opposite first pair of glabellar furrows; facial sutures diverging moderately in front of eyes and intramarginal to center; free cheeks with long genal spine; pygidium essentially as in *Saukia*. **U. Camb.** (central and western N. America).

***S. typicalis** U and R (**260**—26–29). **Trempealeau:** U. Mississippi Valley (Lodi).

S. pepinensis (Owen) (**260**—31–37). Occurs with preceding.

SPHAEROPHTHALMUS Angelin 1854

(**Trilobites alatus* Boeck). Middle lobe of body broad, posterior portion of fixed cheeks narrow, genal spine long and arcuate, eyes spherical and noticeably faceted; thorax with seven to nine segments; pygidium triangular, without spines. **U. Camb.** (Atlantic Province).

S. fletcheri Matthew (**262**—3–6). Genal spine sickle-shaped, long, flat, very wide, and stiffened by two sharp ridges that run along middle; pygidium with a tubercle at each anterior outer corner, and each axial segment with an obscure lobe at each side. **U. Camb.:** N. B. (Narrows).

STENOPILUS Raymond 1924

(**S. pronus*). Differs from *Plethopeltis* in lacking marginal, dorsal, and nuchal furrows, and nuchal spines. **U. Camb.** (N. America).

***S. pronus** Raymond (**260**—10, 11). **Gorge:** Vt.

S. latus Ulrich (**260**—8, 9). **U. Camb.:** Mo. (Eminence), Tex. (L. Ellenburger).

TAENICEPHALUS Ulrich and Resser 1924

(**Conocephalites shumardi* Hall). Differs from *Conaspis* in that fixed cheeks, palpebral lobes, and border surround the glabella, which is cut off square in front as an elevated ridge; depressions at antero-lateral corners of glabella very characteristic; facial suture is intramarginal to center where it cuts margin halfway as in *Conaspis;* pygidium differs in having a flat rim. **U. Camb.** (central and western N. America).

***T. shumardi** (Hall) (**266**—17). **Franconia:** Wis.

TALBOTINA Lochman 1938

(**T. degrasensis*). Cranidium subquadrate with broadly conical glabella; dorsal furrows narrow, well defined; fixed cheeks one-third width of glabella; frontal limb and rim convex, separated by a narrow, well defined transverse furrow; pygidium small, with a strongly convex axial lobe extending nearly full length, marked by three segments and a broad terminal portion; pleural furrows faint; border narrow and flat. **U. Camb.** (Newf.; N. America).

***T. degrasensis** Lochman (**266**—29–31). **U. Camb.:** Newf. (Petit Jardin); Wyo. (Maurice).

T. solitaris Lochman (**266**—32). **U. Camb.:** Mo. (Petit Jardin).

TELLERINA Ulrich and Resser 1933

(**Dikelocephalus crassimarginatus* Whitfield). Differs from typical *Saukia* in having surface markings of inosculating lines, relatively wide convex anterior border, more thickly rimmed free cheeks, stronger genal spines, shallower, narrower, and straighter glabellar furrows, and differences in grooving of pygidial pleural segments; last difference refers to strikingly unequal division of ribs, the anterior part being smaller and much shorter than posterior; usually cranidia and free cheeks of *Tellerina* are smooth in contrast to pustulose nature in *Saukia*. **U. Camb.** (U. Mississippi Valley).

***T. crassimarginata** (Whitfield) (**261**—5; 6). **Trempealeau:** U. Mississippi Valley.

PLATE 267

[Figures are x1 unless otherwise indicated.]

1. Eoharpes ottawaensis [CGS, Pal Fos 1]. **2–7. Cryptolithus** spp. [JP 15]. **2–5. C. tesselatus** (x 2). 2, 3, 5: Anterior, oblique anterolateral, and side views of cephalon. 4: Top view. **6, 7. C. bellulus.** Dorsal view of holotype (x4); dorsal view of a larger specimen (x2). **8, 9. Shumardia granulosa** (x4) [CGS, Pal Fos 1]. Cephalon and pygidium. **10–15. Lonchodomas** spp. **10–13. L. halli** [Carnegie Mus, An 3]. Outline profile and dorsal views of cephalon (x2) and pygidium (x4) respectively. **14, 15. L. normalis** [CGS, Pal Fos 1]. Cranidium and pygidium. **16. Leiostegium quadratum** [CGS, Victoria Mem Mus, B 1]. Pygidium (on left) and cranidium. **17–19. Remopleurides canadensis** [Carnegie Mus, An 3]. Side and dorsal views of cephalon (x2); pygidium (x4). **20–22. Leiostegium puteatum** [Bos Soc N H, B 37]. Incomplete cranidium (x1.3), pygidium, and a free cheek. **23. Bronteopsis gregaria** [MCZ (Harvard), B 67 (1)]. Incomplete cranidium. **24–26. Telephus bicornis** [USNM, Pr 76 (21)]. Dorsal view of free cheek (x4); two large cranidia (x3). **27–29. Hystricurus** spp. **27. H. conicus** [CGS, Victoria Mem Mus, B 1]. Type. **28, 29. H. missouriensis** [Mo G S 24]. Dorsal and lateral views of holotype. **30, 31. Xenostegium belemnurum** [SMC 75 (3)]. Cranidium (x2); dorsal view of type pygidium. **32, 33. Bathyurellus brevispinus** [Carnegie Mus, An 3]. Side and dorsal views of cephalon (x2). **34, 35. Nileus scrutator** [CGS, Pal Fos 1]. Dorsal and side views of cephalon. **36. Bathyurus spiniger** [Carnegie Mus, An 7]. Pygidium with its prominent spine. **37. Bathyurus extans** [Geol Can 1863]. **38. Basilicila barrandei** [MCZ (Harvard), B 58]. Complete dorsal shield, somewhat restored (x1.5). **39–41. Tretaspis reticulata** [JP 15]. Dorsal view of incomplete cephalon (x4); anterolateral view of cephalon (x2); ventral view of incomplete lower lamella (x5). **42, 43. Diplapatokephalus finalis** [photographs furnished by P. E. Raymond]. Cranidium (x5.3); holotype pygidium (x3.8).

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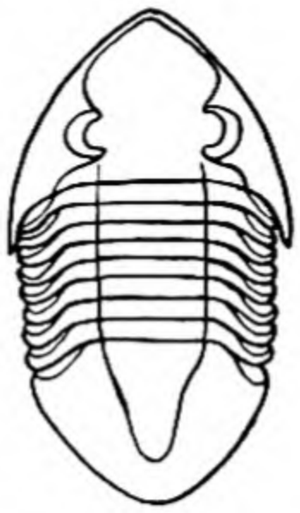

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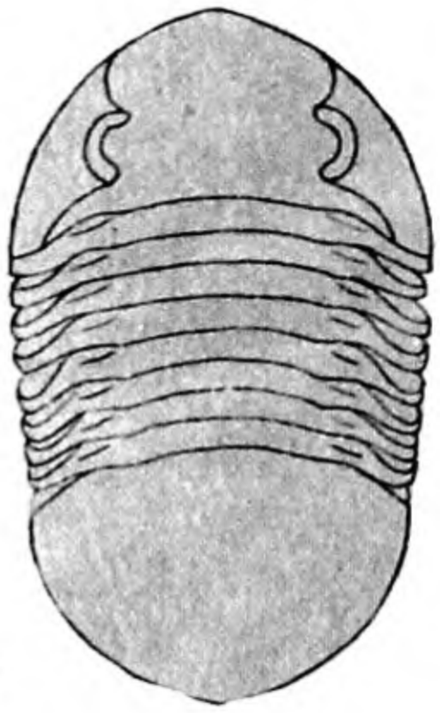

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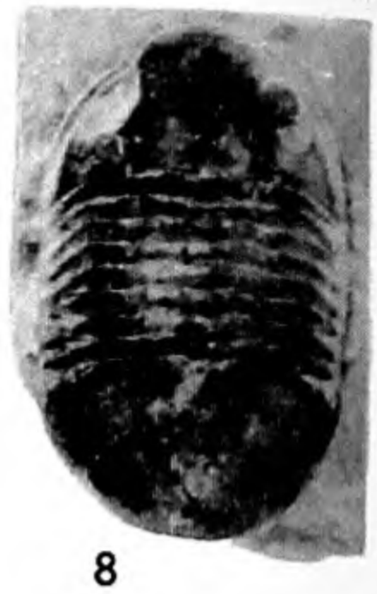

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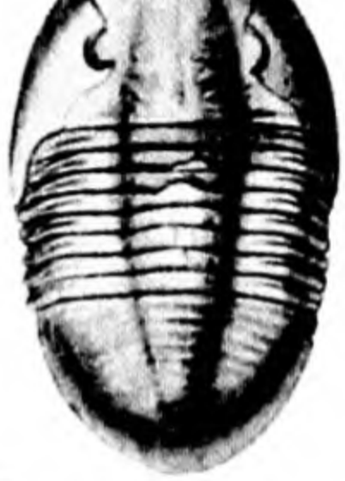

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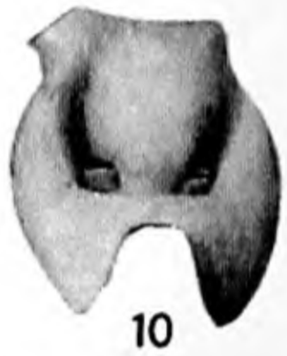

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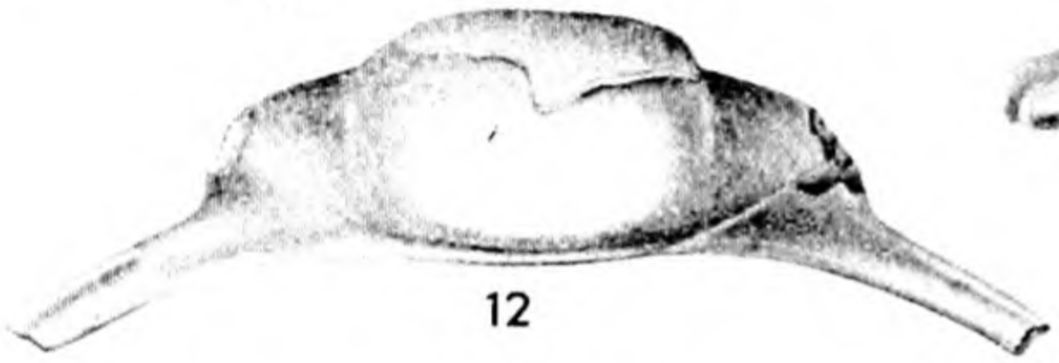

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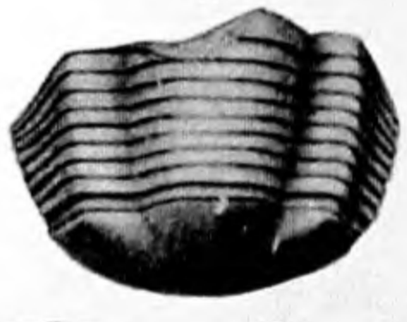

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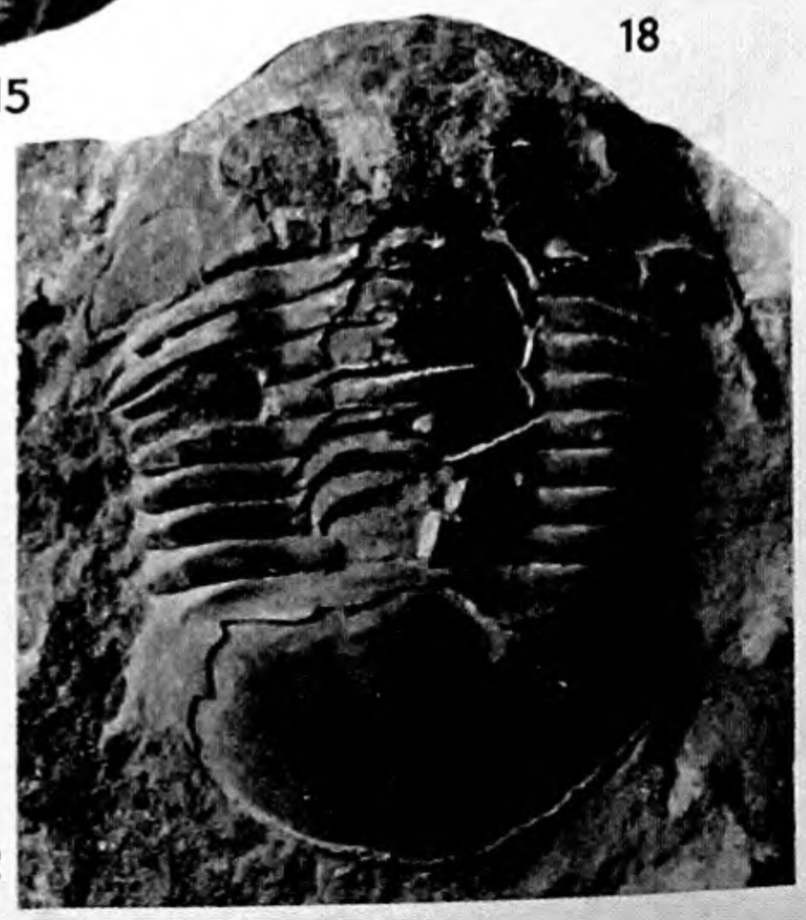

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TERRANOVELLA Lochman 1938

(**T. obscura*). Cranidium small with broad, subquadrate glabella; glabellar furrows in two pairs, short and arcuate; occipital ring with short heavy spines; no frontal border; posterolateral limbs short. **U. Camb.** (Newf.; N. America).

***T. obscura** Lochman (**266**—23). **Petit Jardin:** Newf.

TOSTONIA Walcott 1924

(**Dicellocephalus iole*). Resembles *Olenus* but differs in width of fixed cheeks and course of facial suture, and in spinose pygidium. **U. Camb.** (western N. America).

***T. iole** (Walcott) (**266**—18, 19). **U. Camb.:** Nev.

TRIARTHROPSIS Ulrich 1930

(**T. nitida*). Glabella subparallel sided, rounded anteriorly, furrows in three posteriorly directed pairs, some of which are complete; occipital ring thicker in middle, set off by strongly impressed furrow; occipital spine lacking; posterolateral limbs triangular; surface smooth. **U. Camb.** (Mississippi Valley).

***T. nitida** Ulrich (**266**—7, 8). **Eminence:** Mo.

TRICREPICEPHALUS Kobayashi 1935

(**Arionellus* (*Bathyurus*) *texanus* Shumard). Cranidium with prominent frontal furrow marked by three pits; pygidium massive, nearly square, with two long spines extending out from pleural lobes on each side above posterolateral margin. **U. Camb.**

***T. texanus** (Shumard) (**262**—25–28). **U. Camb.:** Tex.

T. tripunctatus (Whitfield) (**262**—11). **Pilgrim:** Mont.

T. cedarensis Resser (**262**—24). **U. Camb.:** Ala.

UNCASPIS Kobayashi 1935

(**Crepicephalus unca* Walcott). Cranidium narrow, elongate; glabella broadly conical, glabellar furrows obsolete or very faint; frontal limb of variable width, downsloping; frontal border uptilted, triangular; free cheeks narrow, nonexistent in midportion except for long narrow palpebral lobes; posterolateral limbs broad; occipital ring broad and flat with a slender occipital spine; pygidium large, provided with a conical axial lobe pointed backward, and relatively wide border from which a pair of posterior spines is produced. **U. Camb.** (N. America).

***U. unca** (Walcott) (**266**—25–27). **Eau Claire:** U. Mississippi Valley.

U. micans Resser (**266**—28). **Nolichucky:** Tenn.

WELLERASPIS Kobayashi 1935

(**Solenopleura jerseyensis* Weller). Glabella subrectangular; brim curved upward at front; fixed cheeks narrow; pygidium small with segmented axial and pleural lobes. **U. Camb.** (eastern N. America).

***W. jerseyensis** (Weller) (**266**—24). Glabella with two pairs of furrows, anterior pair very faint and transverse, posterior stronger and arched backward; entire glabella tapers backward into a very broad triangular spine; neck furrow deep, causing slight separation of spine and glabella. **Kittatinny:** N. J.

WILBERNIA Walcott 1924

(**Ptychoparia pero*). Glabella rectangular in outline, furrows in two pairs, visible on inner surface of test; occipital ring strongly defined; fixed cheeks one-third width of glabella; eyes moderately large, located back of middle of glabella; palpebral lobes raised into bosslike protuberances in some species; facial sutures diverge in front of eyes and are intramarginal for some distance; posterolateral limbs long, narrow; rim wide and well defined by a shallow furrow. **U. Camb.** (central and western N. America).

***W. pero** (Walcott) (**266**—20–22). **Wilberns:** Tex.

POST-CAMBRIAN TRILOBITA

[Genera arranged alphabetically]

ACASTE Goldfuss 1843

(**Calymene? downingiae* Murchison). Phacopids in which glabellar furrows converge toward a common point; third the deepest. **Sil.** (eastern N. America; England).

***A. downingiae** (Murchison) (**274**—13). **Pembroke:** Me.

ACHATELLA Delo 1935

(**Dalmanites achates* Billings). Cephalic margin broadly rounded, frontal lobe very alate; third lateral lobes unreduced; nuchal lobe broad and elevated; eyes conical; pygidium subtriangular, indistinctly bordered, with wide furrowed pleural ribs and narrow interpleural furrows. **M.** and **U. Ord.**

PLATE 268

[Figures are x1 unless otherwise indicated.]

1–3. Isotelus spp. **1. I. iowensis** (x1.5) [MCZ (Harvard), B 58]. **2, 3. I. gigas.** A small specimen showing all characteristics of adult [MCZ (Harvard), B 58]; outline drawing showing generic features [Carnegie Mus, An 7]. **4, 5. Vogdesia bearsi** [Carnegie Mus, An 3]. Front and top views of different cranidia. **6–8. Homotelus** spp. **6, 7. H. obtusus** [Carnegie Mus, An 3]. Outline of complete specimen; pygidium and five thoracic segments. **8. H. ulrichi** [MCZ (Harvard), B 67]. Holotype (x0.7). **9, 10. Isoteloides canalis** [Carnegie Mus, An 7]. Small complete specimen, and hypostoma. **11–15. Thaleops ovata** (x2) [Carnegie Mus 4]. Posterior and anterior views of cephalon; anterior, anteroventral, and dorsal views of an enrolled specimen. **16–18. Illaenus americanus** (x1.3) [Carnegie Mus, An 4]. Cranidium (lighted to be viewed from front), pygidium, and specimen with most of thorax and pygidium. **19. Isotelus brachycephalus** (x0.5) [DUB, JSL 19]. **20, 21. Vogdesia vigilans** [Minn G S 3 (2)]. Side and dorsal views of an enrolled specimen. **22. Brachyaspis notans** [R Soc Can, Tr (3) 5 (4)]. Type.

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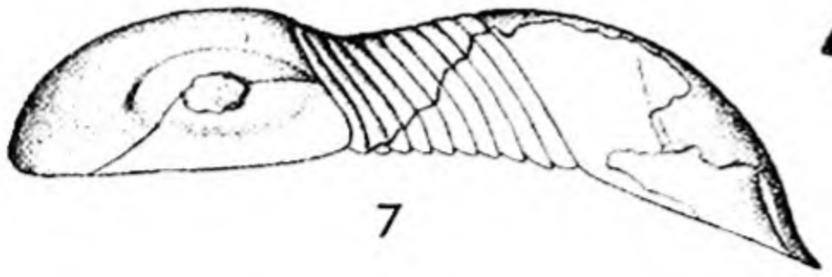

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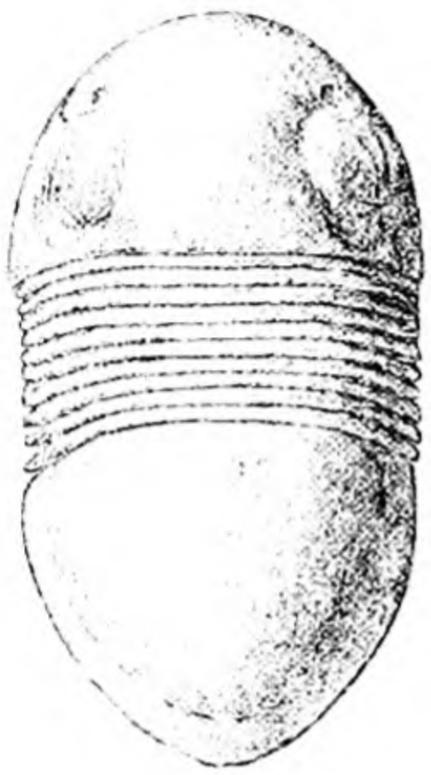

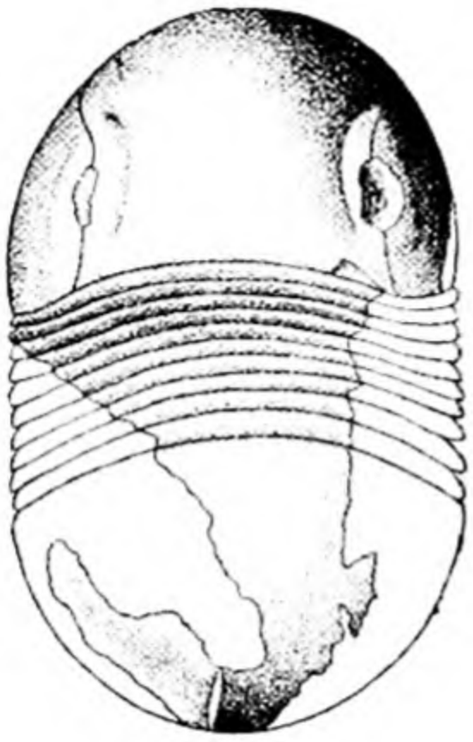

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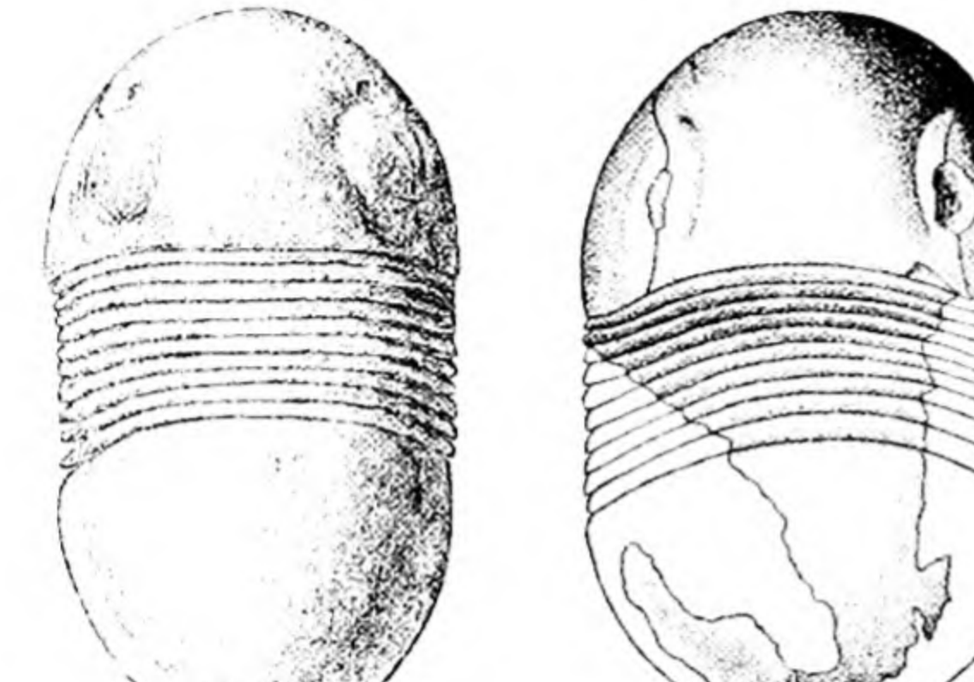

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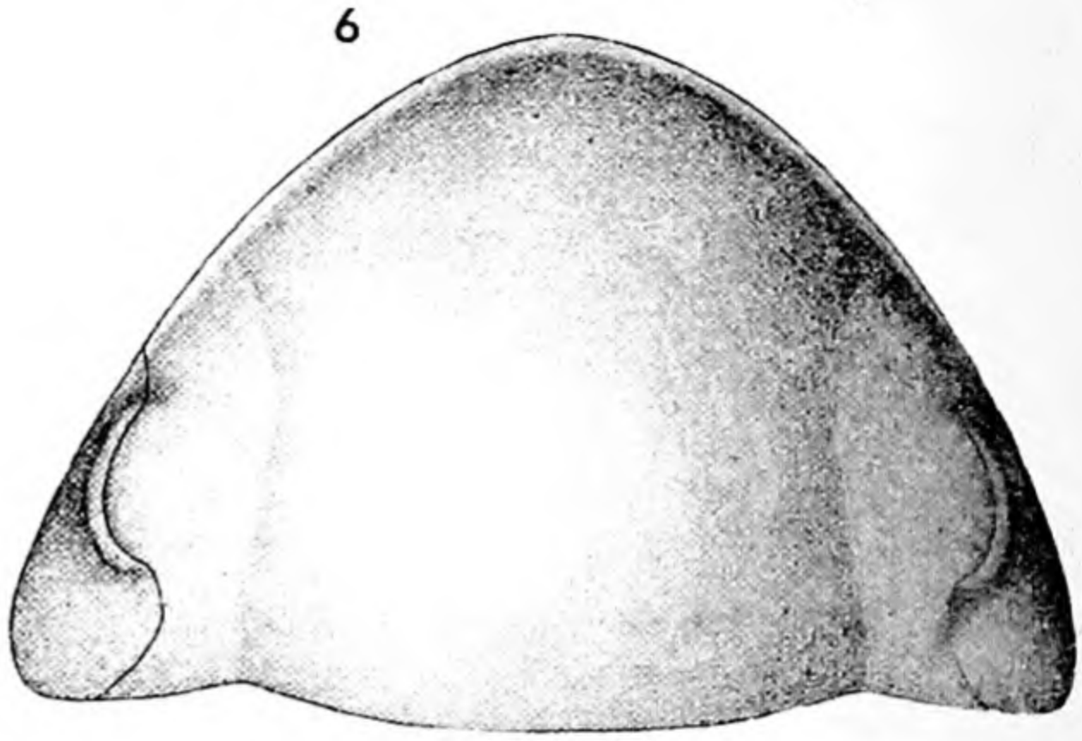

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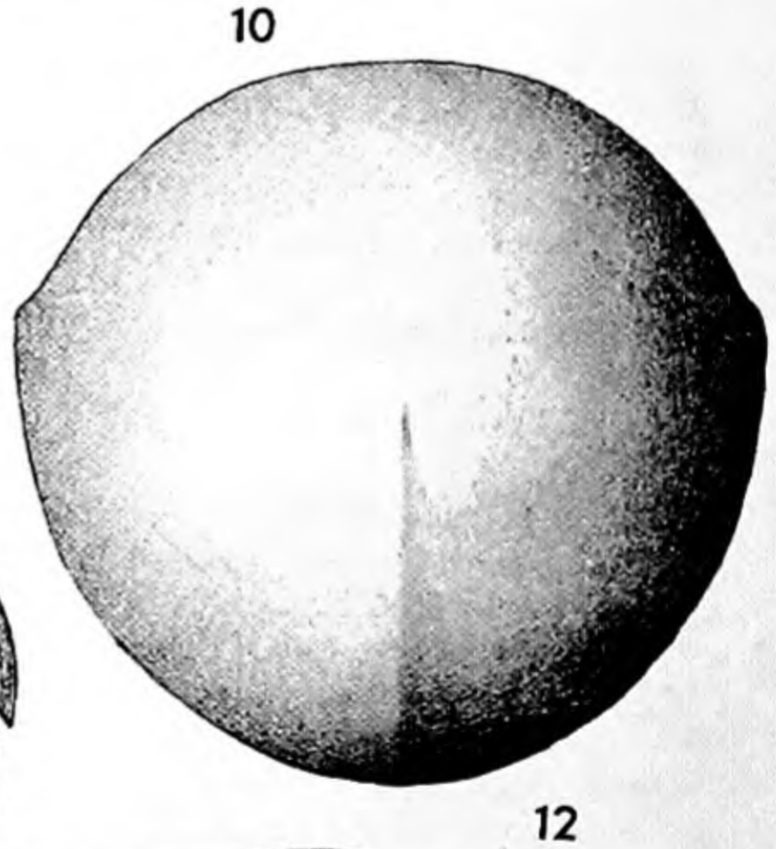

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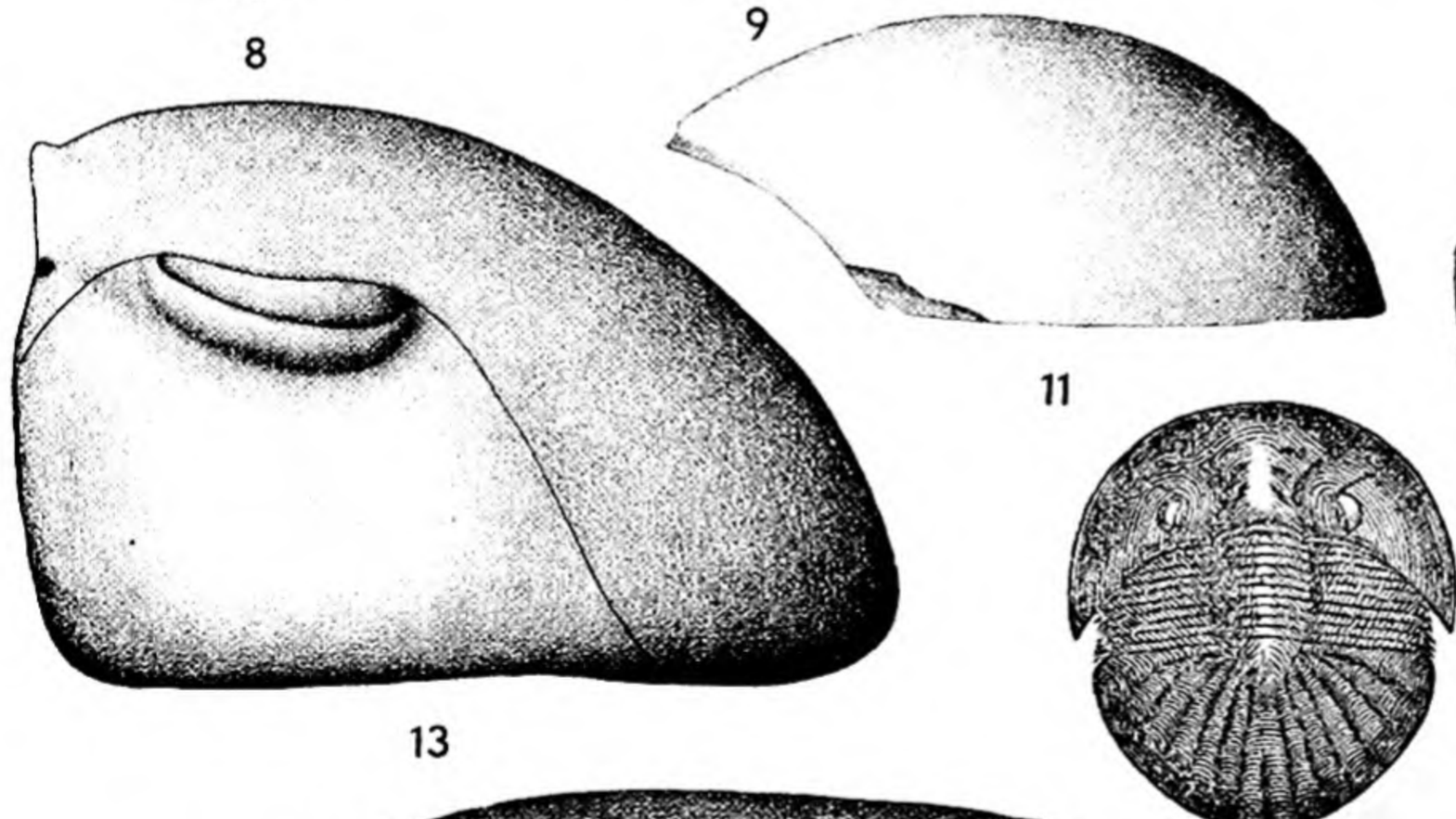

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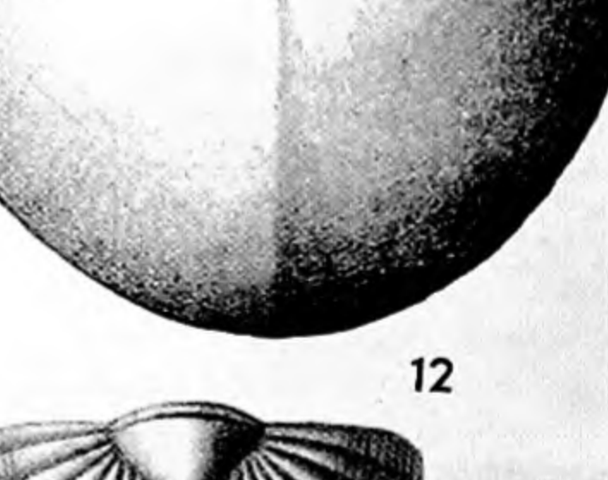

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***A. achates** (Billings) (**273**—17). **Trenton:** Ont.; N. Y. Apparently conspecific forms in equivalent strata of Mississippi Valley.

ACROLICHAS Foerste 1919

(**Lichas cucullus* Meek and Worthen). Glabella differs from *Tetralichas* in having median lobe produced dorsally in conelike projection. **M. Ord.**

***A. cucullus** (M and W) (**270**—19–22). **Kimmswick:** Mo., Ill.

A. cucullus ottawaensis Foerste (**270**—23, 24). **Trenton:** Ont.

ALSATASPIS Turner 1940

(**A. bakeri*). Cephalon broad, provided with a long anterior spine and genal spines which project widely and sweep backward; thorax long, uniformly tapering with numerous segments, and broadest some distance behind base of cephalon; pygidium small, usually not well defined; species associated with graptolitic assemblages. **L. Ord.** (Newf.; Tex.).

A. evansi Kindle (**274**—1). Like *A. bakeri*, but pygidium more clearly defined, and genal spines are attached farther forward. **L. Ord.:** Newf.

AMEURA Weller 1936

(**Phillipsia sangamonensis* Meek and Worthen). *Ameura* differs from all other American Carboniferous genera in the form of its glabella, which is much the widest between the eyes; and it is the only genus which appears to lack ornamentation. **Penn., Perm.**

***A. sangamonensis** (M and W) (**275**—25–27). **Penn., Perm.:** N. America.

A. major (Shumard) (= **Proetus longicaudus** Hall = **Phillipsia nodocostata** Hare) (**275**—23, 24). **Penn.:** Mo., Neb., Kan., Colo., Mont.

ANCHIOPSIS Delo 1935

(**Calymene anchiops* Green). Like *Synphoria*, with cephalon short and wide, glabellar lobes confluent and highly elevated distally, second and third pairs of lateral furrows represented by rounded pits; pygidium triangular, with short, triangular, upturned spines, and with about 15 axial annulations. **L.** and **M. Dev.**

***A. anchiops** (Green) (**274**—20–22). **Oriskany:** Ont.; **Schoharie:** N. Y.; **Onondaga:** Ont.; N. Y., Falls of Ohio.

ANISOPYGE Girty 1908

(**Phillipsia perannulata* Shumard). Cephalon with low convexity and wide border; glabella much enlarged in front and divided by a strong marginal furrow; genal angles absent; pygidium with folding under of border, development of a smooth band along edges on axis, and many axial segments which are independent of the few pleural segments; the former number variable, the latter constant. **Perm.** (southwestern U. S. A.).

***A. perannulata** (Shumard) (**275**—19–22). **Perm.:** Tex. (Capitan, Delaware Mt.).

ARCTINURUS Castelnau 1843

(= PLATYNOTUS Conrad 1838)

(**Paradoxides boltoni* Bigsby). Glabella with quadricomposite lateral lobes; third lateral furrows indicated mesially; longitudinal furrows extending to occipital furrow, but very weakly developed behind position of third lateral furrows; cephalon produced anteriorly in a median tonguelike projection; pygidium with three pairs of pleura having free points; axial lobe with two furrows and flaring posteriorly. **Sil.** (eastern Canada and northeastern U. S. A.).

***A. boltoni** (Bigsby) (**271**—1, 8, 10, 19). Glabella with an anterior nasute extension; eyes usually crushed, looking in form and position like a second pair of lateral lobes; pygidium wider than long, deeply notched. **Clinton:** Ont.; N. Y.

A. occidentalis (Hall) (**271**—17, 18). Pygidium with two lateral margins nearly parallel; differs from preceding in having pleural segments of pygidium more elongate and directed more nearly in a posterior direction. **Niagaran:** Ind., Tenn., Ill.

A. nereus (Hall) (**271**—9). Differs from *A. boltoni* in that post-axial lobe of pygidium has a rounded outline with a small median notch. **Niagaran:** N. Y., Ark.

BASILIELLA Kobayashi 1934

(**Asaphus barrandei* Hall). Pygidium is semicircular and marked by about 10 ribs and furrows. **Ord.** (N. America; Argentina).

***B. barrandei** (Hall) (**267**—38). Cephalon large, with wide free cheeks and long, flattened genal spines; glabella raised, with two pairs of nodes and a prominent median pustule near nuchal furrow; pygidium semicircular, with seven or eight pairs of prominent ribs. **M. Ord.:** Ont.; N. Y., Va., Wis., Minn.

BATHYURELLUS Billings 1865

(**B. abruptus*). Glabella smooth, low, pointed in front; practically all of pygidium except axial lobe is concave. **Ord.** (Newf.; eastern N. America; Ireland).

PLATE 269

[Figures are x1 unless otherwise indicated.]

1–14. Bumastus spp. 1, 2. B. globosus. Side and top views of an enrolled specimen, from original drawings by G. H. Hudson. **3–6. B. milleri** [Carnegie Mus, An 4]. Side and dorsal views of a specimen (x2); dorsal and anteroventral views of a very small specimen (x4). **7–9. B. niagarensis.** 7, 9: Side and top views of an incomplete specimen [Chicago Ac Sc, B 4 (2)]. 8: Dorsal view of a complete dorsal shield [MCZ (Harvard), B 60]. **10–12. B. insignis** [Chicago Ac Sc, B 4 (2)]. Dorsal view of cephalon; side and top views of pygidium. **13, 14. B. ioxus** [Chicago Ac Sc, B 4 (2)]. Side and top views of complete cephalon. **15–17. Scutellum spp. 15. S. lunatum** [Geol Can 1863]. **16. S. barrandi** [N Y St Mus, B 9]. Pygidium (x3). **17. S. acamas** [Chicago Ac Sc, B 4 (2)]. Pygidium.

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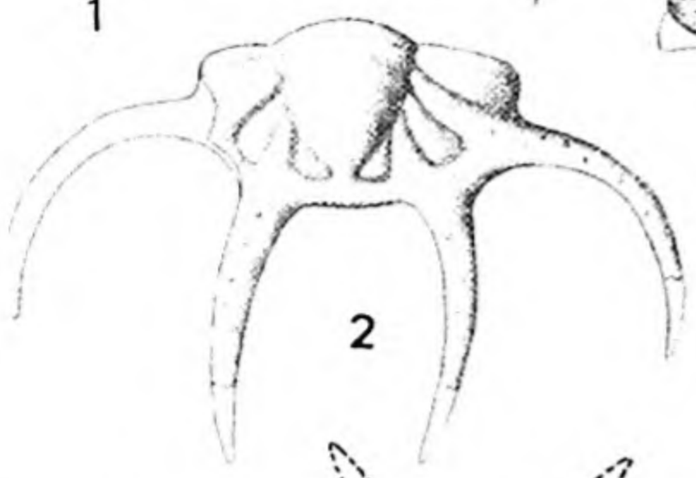
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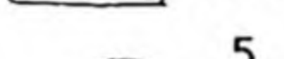
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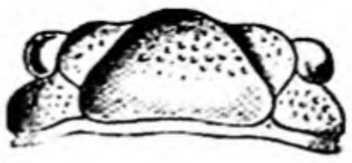
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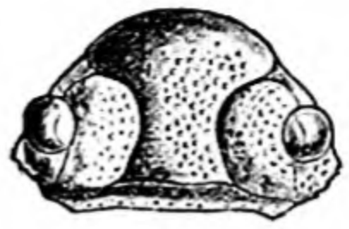
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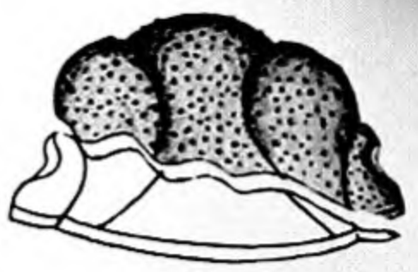
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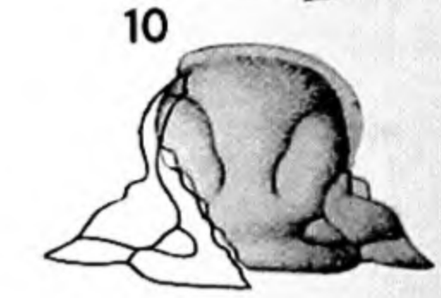
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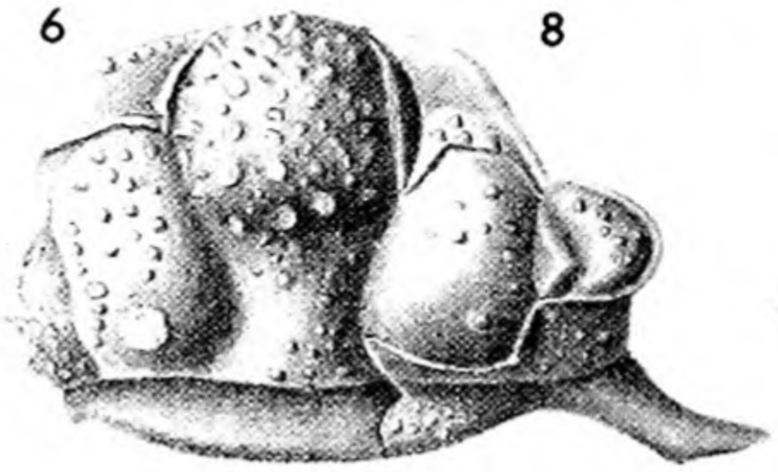
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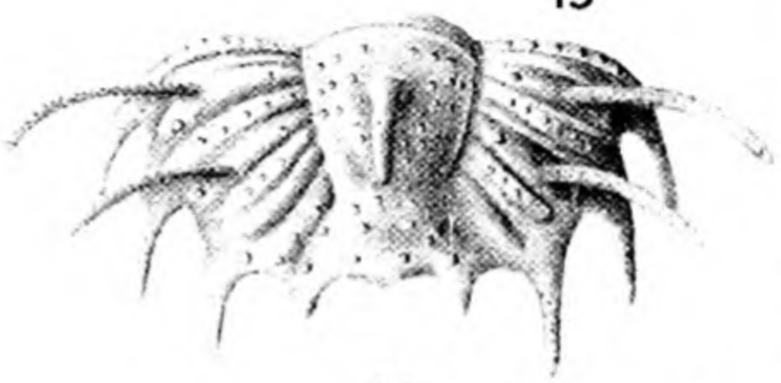
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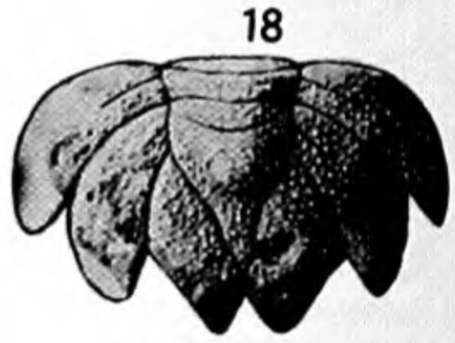
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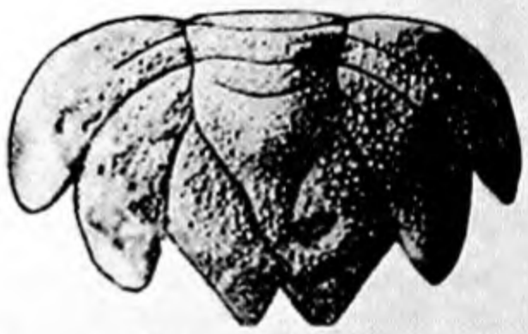
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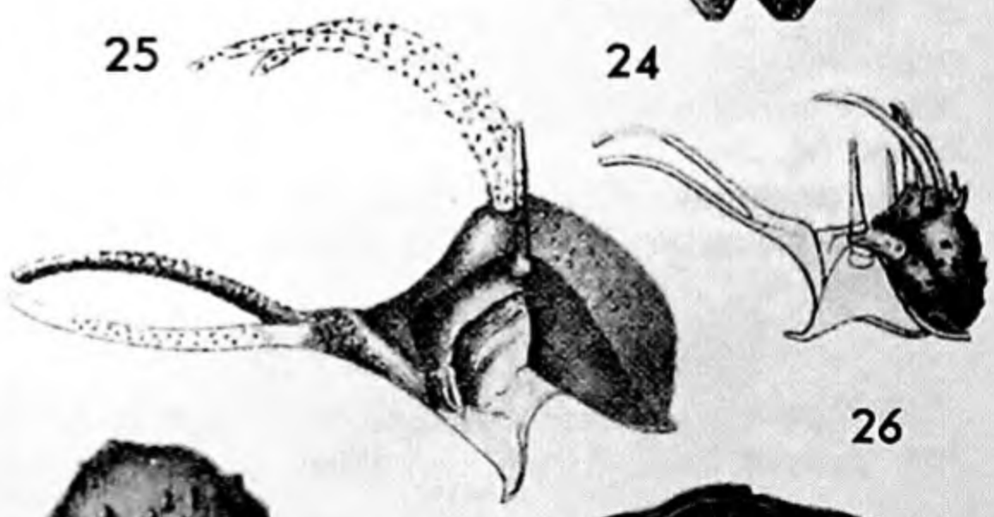
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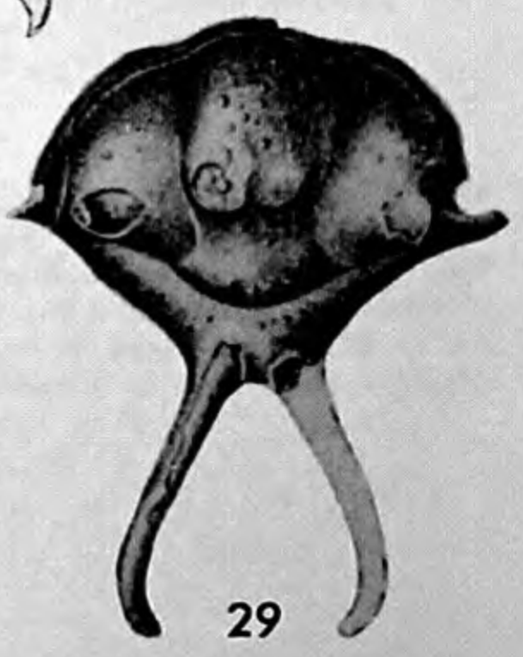
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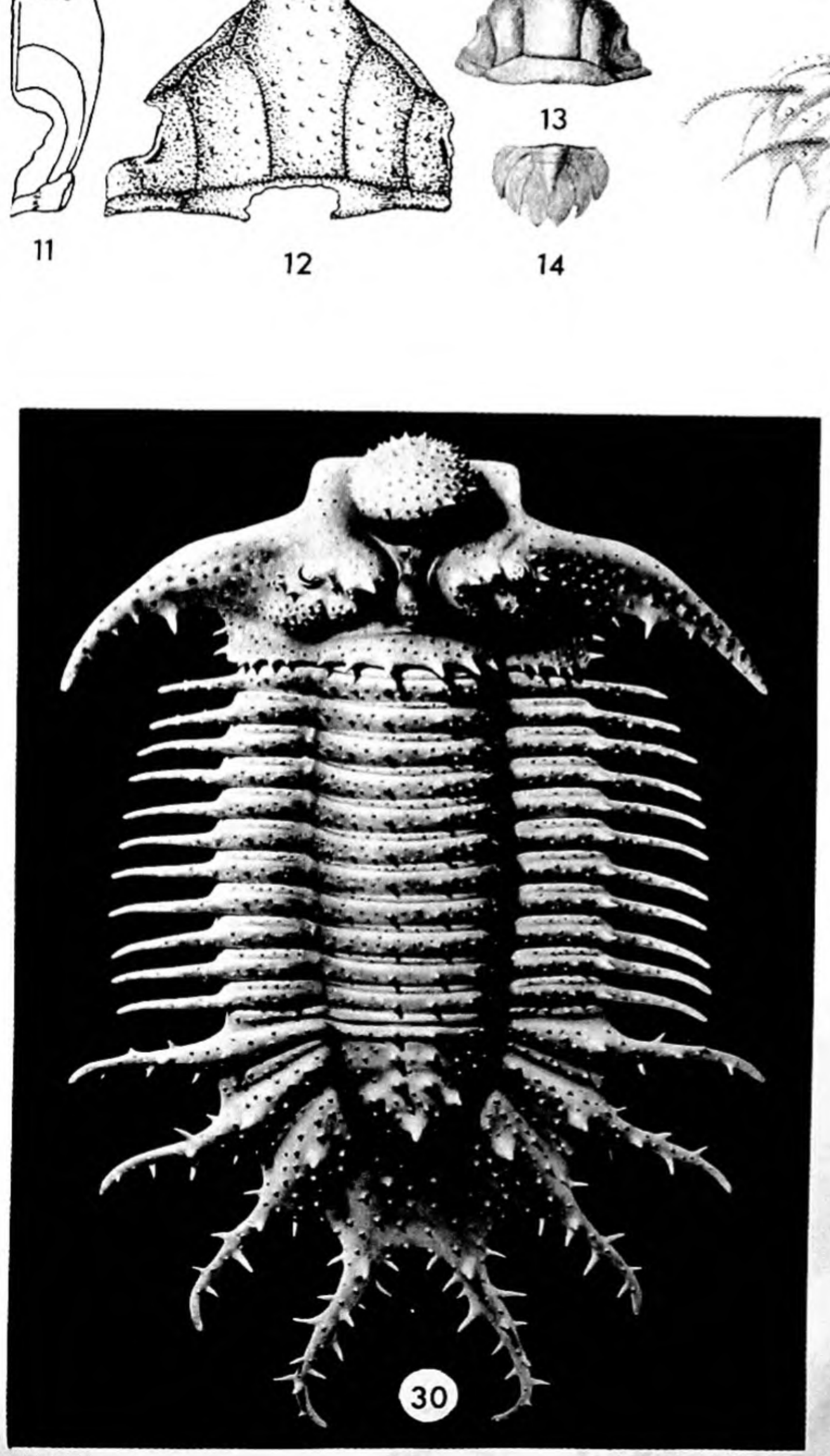
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B. brevispinus Raymond (**267**—32, 33). Genal spines short; pygidium with only obscure traces of ribs. **Chazyan:** Mingan Islands, Que.; N. Y. (Day Point).

BATHYURUS Billings 1859

(**Asaphus extans* Hall). Cephalon large, with long, flat genal spines; glabella long, high, smooth or with obscure furrows; brim narrow, concave, without rim; eyes large, close to glabella; pygidium strongly convex, with three or four pairs of smooth ribs. **Ord.**

***B. extans** (Hall) (**267**—37). Very convex; pygidium with a prominent axis and thickened margin. **Black River:** Que., Ont.; N. Y., Ky., Wis., Minn.

B. spiniger Hall (**267**—36). Differs from preceding in its broader frontal border, in presence of an occipital spine, in its tuberculate glabella, and in presence of a prominent pygidial spine. **Black River:** Que.; N. Y., Ind., Ky., Ill., Ia., Mo.

BRACHYASPIS Salter 1866

(**Isotelus rectifrons* Portlock). Similar to *Homotelus*, but with more convex, shorter, and wider shields; axial lobe wide; pygidium smooth. **U. Ord.** (N. America).

B. notans Billings (**268**—22). Genal spines present. **Richmond:** Anticosti.

BRACHYMETOPUS McCoy 1847

(**B. strzeleckii*). Like *Phillipsia* but with glabella very short and pygidium generally granulose. **Dev.–Perm.**

B. lodiensis Meek (**275**—28). **Waverly:** Ohio.

B. armatus Vogdes (**275**—13–15). **Chouteau:** Mo.

B. spinosus (Herrick) (**275**—16–18). **Miss.:** Ohio (Waverly), Mo. (Chouteau).

BRONTEOPSIS Nicholson and Etheridge 1879

(**B. scotica*). Isopygous; glabella low, expanding toward the front, smooth or with three pairs of pits; eyes far back; pygidium smooth, axial lobe long, narrow, with rings at anterior end. **Ord.** (Newf.; eastern N. America; Great Britain; Sweden).

B. gregaria Raymond (**267**—23). Glabella with only faint traces of pits. **Chazyan:** Newf.; Va., Tenn.

BUMASTUS Murchison 1839

(**B. barriensis*). Differs from *Illaenus* in having an extremely wide axial lobe and with dorsal furrows of cephalon reduced to reniform depressions; many species have concave borders on pygidium and a few have narrow ones on cephalon; axial lobe of pygidium not outlined. **Ord., Sil.** (N. America; Europe).

B. globosus (Billings) (**269**—1, 2). Dorsal furrows on cephalon usually well developed; no concave borders. **Chazyan:** Que.; Vt., N. Y., Tenn.

B. milleri (Billings) (**269**—3–6). Similar to preceding, but dorsal furrows are represented only by faint depressions on cephalon. **Black River, Trenton:** Que., Ont.; N. Y., N. J., Pa., Ind., Wis., Ill., Minn.

B. ioxus (Hall) (**269**—13, 14). Shields large; eyes long with a bulge below the visual area, and a conspicuous depression below that. **Niagaran:** Widespread throughout eastern and central N. America.

B. niagarensis (Whitfield) (**269**—7–9). Cephalon with long dorsal furrows; pygidium long, rather pointed behind, with narrow concave border. **Niagaran:** Ohio; Wis., Ill., Mo.

B. insignis (Hall) (**269**—10–12). Cephalon parabolic in outline, strongly convex; dorsal furrows terminate near anterior margin of cephalon in pitlike depressions; eyes several times as long as high; anterior and lateral margins bent slightly upward, forming a narrow, liplike border; pygidium usually with a slight median longitudinal ridge extending from near center to posterior extremity. **Niagaran:** Ohio, Ind., Wis., Ill.

CALLIOPS Delo 1935

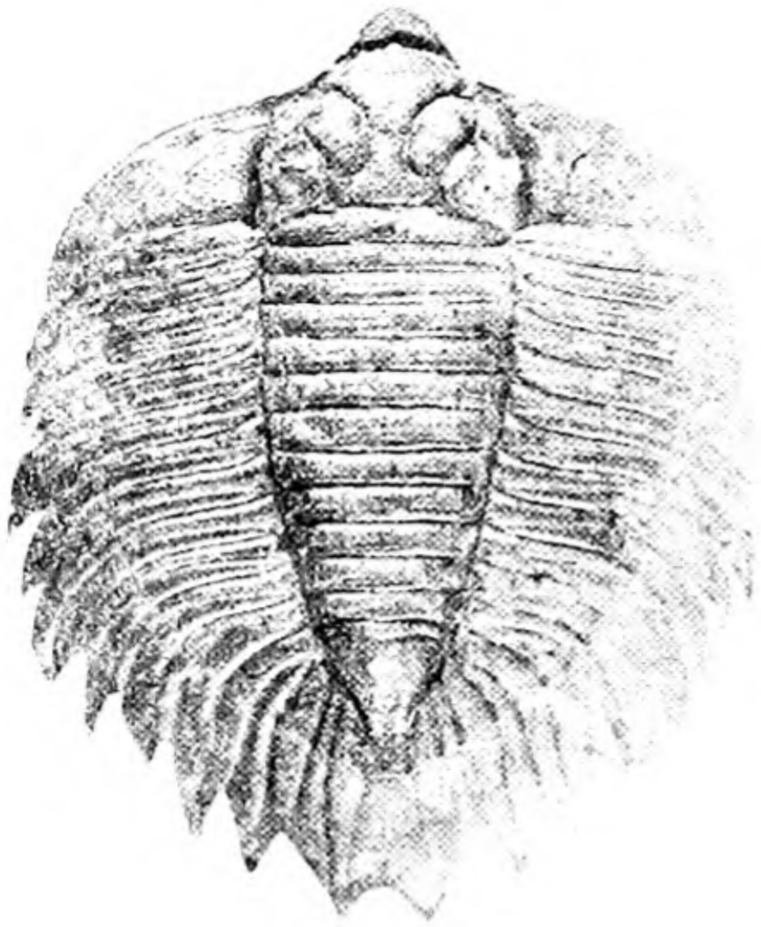
(**Phacops callicephalus* Hall). Frontal lobe not conspicuously alate, sharply bounded, only slightly wider than large first glabellar lobes, which are distinctly triangular; second glabellar furrows narrower, shallower than first and third; eyes large, with conspicuously swollen palpebral lobes reaching backward to posterior marginal furrow; nuchal lobe prominent; pygidium convex, never mucronate. **Ord.**

***C. callicephala** (Hall) (**273**—20–23). **Trenton:** N. Y. and adjacent states; very similar forms in **Platteville** and **Trenton,** or their stratigraphic equivalents, in Mississippi Valley.

PLATE 270

[Figures are x1 unless otherwise indicated.]

1–4. Trochurus phlyctanoides [Chicago Ac Sc, B 4 (2)]. Dorsal view of slightly distorted cranidium; nearly complete pygidium; lateral and dorsal views of a nearly complete cranidium. **5. Kerakephalichas rhinoceras** [Field Mus N H, Pub g s 4 (3); JP 10]. Outline restoration of type (x0.4). **6–10. Tetralichas** spp. **6. T. clermontensis** [Field Mus N H, Pub g s 4 (3)]. Dorsal view of type cranidium. **7, 8. T. jukesi** [CGS, Pal Fos 1]. Front and top views of cephalon. **9, 10. T. trentonensis** [Pal N J 3]. Dorsal and anterior views of a nearly complete cranidium. **11, 12. Kerakephalichas bicornis** [Am G 10]. Outline profile and dorsal views of an incomplete cranidium. **13, 14. Tetralichas minganensis** [Carnegie Mus, An 3]. Cranidium; a small pygidium (x1.3). **15, 16. Echinolichas eriopis** (x2) [Pal N Y 7]. Incomplete cephalon; complete pygidium. **17, 18. Lichas ferrisi** [Chicago Ac Sc, B 4 (2)]. Incomplete cranidium; pygidium. **19–24. Acrolichas** spp. **19–22. A. cucullus** [AJS (4) 49]. Lateral view of cranidium; pygidium; cranidium and free cheek, slightly reduced. **23, 24. A. cucullus ottawaensis** [DUB, JSL 19]. Cranidium (slightly reduced); pygidium. **25–29. Ceratolichas** spp. [Pal N Y 7]. **25–27. C. dracon.** Imperfect cephalon, viewed dorsally and laterally; portion of frontal lobe of glabella (x2). **28, 29. C. gryps.** Incomplete cephalon (x2) viewed laterally and dorsally. **30. Terataspis grandis** [photograph furnished by I. G. Reimann]. Restoration of complete dorsal shield (x0.25).



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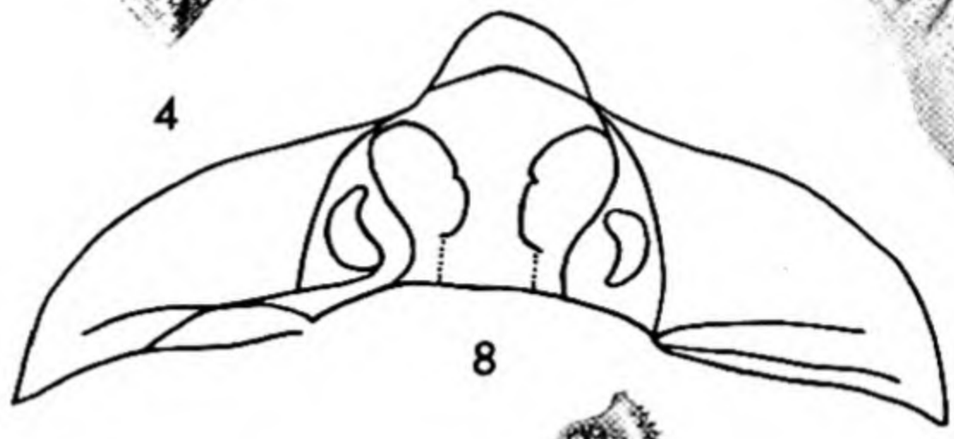

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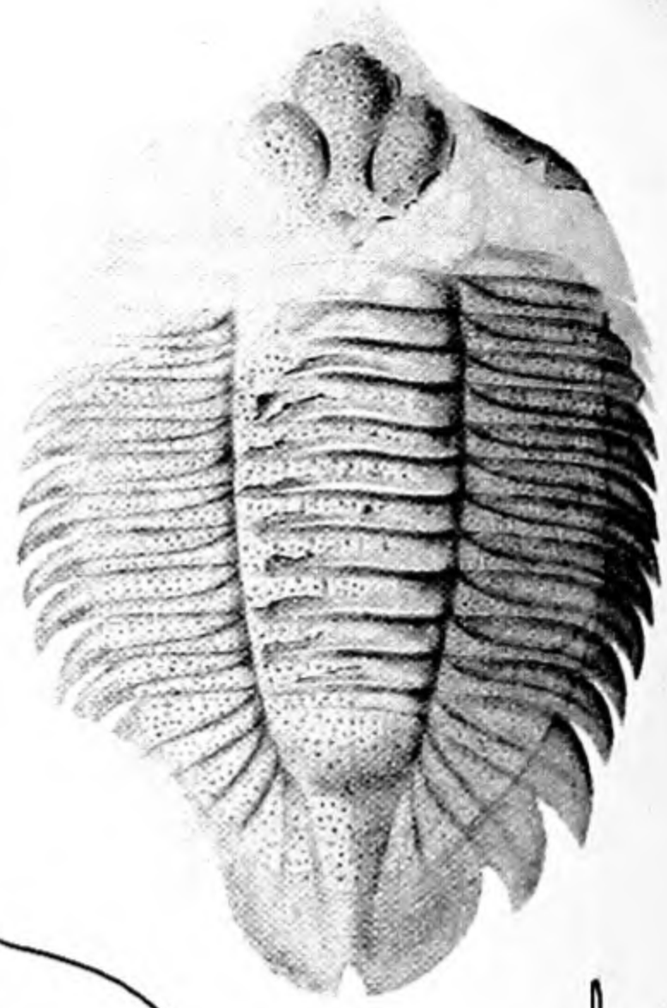

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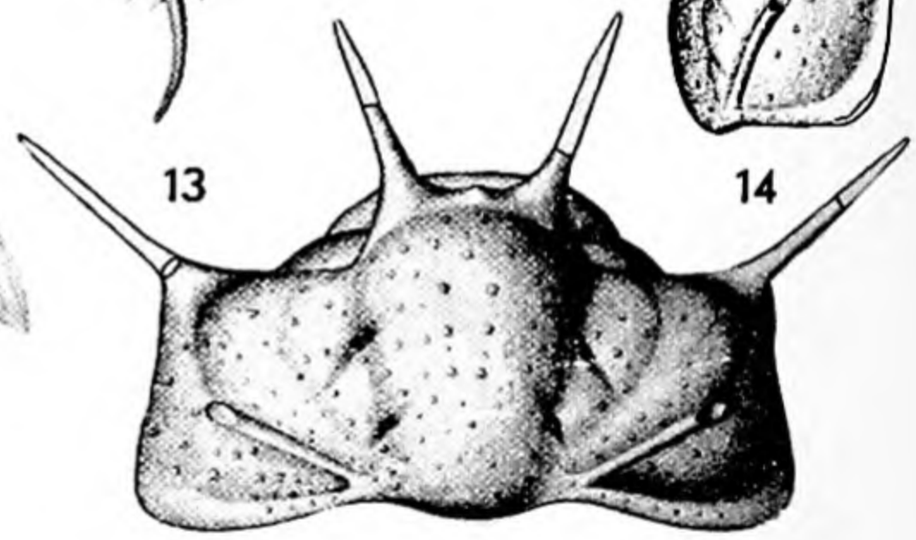

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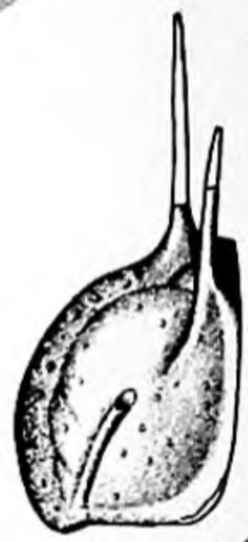

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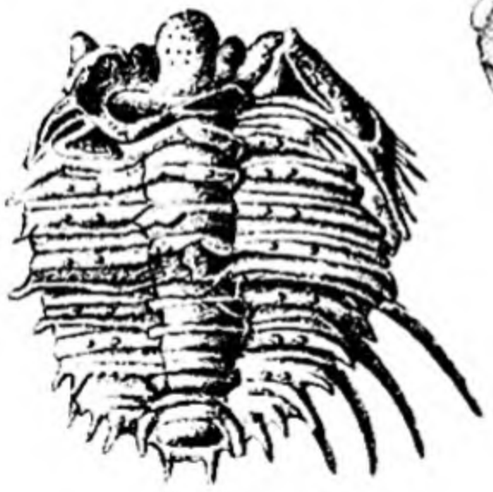

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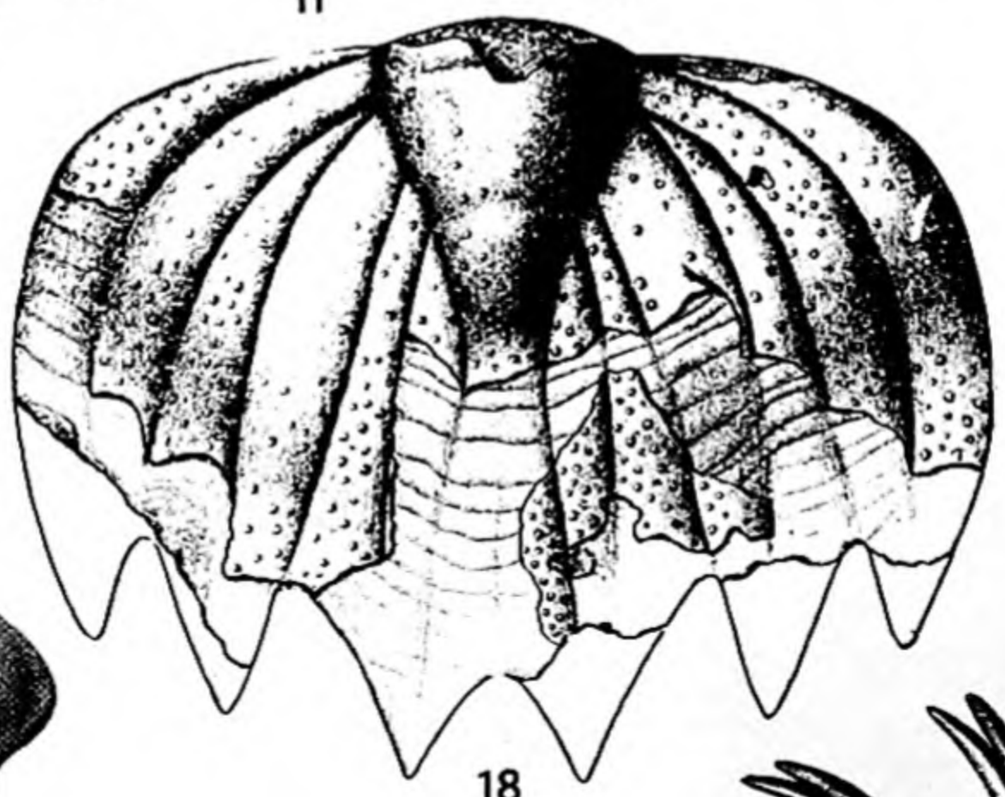

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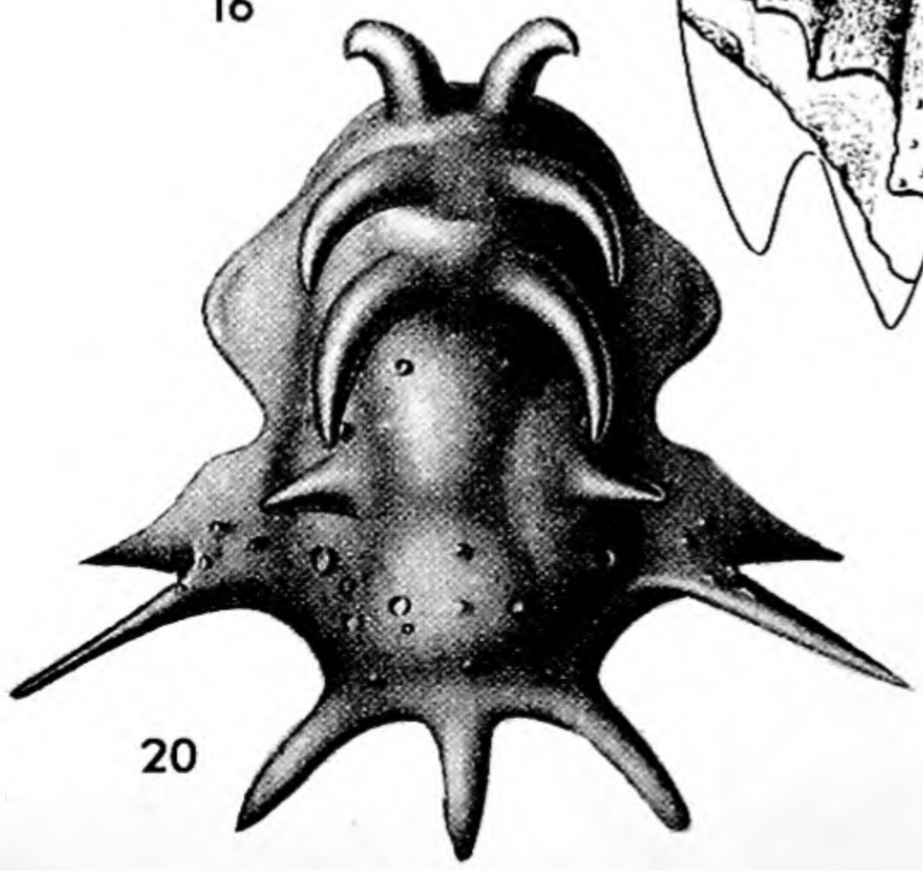

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CALYMENE Brongniart 1822

(**C. blumenbachi*). Cephalon with narrow rim separated from glabella by the intramarginal furrow — in this respect differing from *Flexicalymene;* dorsal furrows constricted opposite eyes. **Sil.–M. Dev.** (N. America; Europe).

C. celebra Raymond (**272**—6, 7). Pygidium with broad smooth margin not crossed by the unfurrowed ribs. **Niagaran:** Widespread throughout N. America, and usually identified as **C. niagarensis** Hall.

C. platys Green (**272**—8–10). Large; hypostoma subquadrate, with a notch on each of the four sides; glabella almost parallel sided, tapering but slightly forward. **Dev.** (Onondaga): N. Y. (Schoharie), Ind.

CALYPTAULAX Cooper 1930

(**C. glabella*). First and second lateral lobes coalesced; second lateral furrows very shallow, not reaching dorsal furrow; eyes very long. **Ord.**

***C. glabella** Cooper (**273**—24–26). **M. Ord.:** Widespread throughout N. America.

CERATOCEPHALA Warder 1838

(**C. goniata*). Spinose forms allied to *Odontopleura*, but with free cheeks ankylosed to cranidium and with posterior part of glabella bearing a pair of long, straight spines which extend above the smooth nuchal ring. **U. Ord.–L. Dev.** (N. America; Europe; Australia).

***C. goniata** Warder (**271**—14, 15). **M. Sil.** (Niagaran): Que.; Ohio, Wis., Ill.

CERATOLICHAS Hall and Clarke 1888

(**Lichas (Ceratolichas) gryps*). Cephalon strongly arched with two pairs of recurved spines; lobes quadricomposite; one pair of occipital spines. **M. Dev.**

***C. gryps** (H and C) (**270**—28, 29). **Onondaga:** N. Y.

C. dracon (H and C) (**270**—25–27). **Onondaga:** N. Y.

CERAURINUS Barton 1913

(**C. marginatus*). Differs from *Ceraurus* in that the surface is almost smooth, the posterior glabellar lobes are not isolated, and the pygidium has three pairs of short blunt subequal spines. **M.** and **U. Ord.** (N. America; northern Europe).

C. icarus (Billings) (**272**—15). **Richmond:** Anticosti; Ohio, Ind., Ia.; Man.

CERAURUS Green 1832

(**C. pleurexanthemus*). Cephalon semicircular; glabella strongly convex, subquadrate or expanding anteriorly, without brim or rim; three pairs of glabellar furrows, the last turned backward, isolating square glabellar lobes; eyes small, considerably removed from glabella; genal spines on fixed cheeks; thorax usually with 11 segments, rarely 9 to 13; pleura flattened for some distance and then curved downward and backward; pygidium small, with one pair of long spines. **Ord.** (N. America; Europe).

***C. pleurexanthemus** Green (**272**—14). Glabella broadest in front; entire cephalic surface strongly papillose. **Black River, Trenton:** Widespread throughout eastern and central N. America.

CHEIRURUS Beyrich 1845

(**C. exsul*). Differs from *Ceraurus* in having triangular basal glabellar lobes and in the radiating, subequal spines on pygidium. **Sil.** (N. America; Europe).

C. welleri Raymond (**272**—11, 12). Cephalon semicircular; glabella long, gradually expanding anteriorly; frontal lobes occupy less than half the length; glabellar furrows long, curving backward with last pair meeting and inner ends of others close together; free cheeks small, with eyes opposite ends of second pair of glabellar furrows and near dorsal furrows; free cheeks wide, pitted, and with short genal spines; pygidium not known certainly. **Niagaran:** Ont.; N. Y., Ind., Tenn., Wis.

C. niagarensis (Hall) (**272**—13). **Niagaran:** Eastern and central N. America.

CORDANIA Clarke 1892

(**Phaethonides cyclurus* Hall). Cephalon with thickened, usually elevated margin, continued into short genal spines; glabella short, ovoid, with two conspicuous basal lobes; pygidium subsemicircular; test tuberculate. **Dev.** (N. B., Que.; Me., N. Y., Md.).

C. becraftensis Clarke (**274**—23, 24). **L. Dev.:** Que. (Grande Grève); N. Y. (Oriskany).

CORONURA Hall and Clarke 1888

(**Asaphus aspectans* Conrad). Like *Synphoria*, except that pygidium has numerous lateral spines and a crescentic, spinose terminus. **M. Dev.** (N. America).

PLATE 271

[Figures are x1 unless otherwise indicated.]

1. Arctinurus boltoni [photograph furnished by N Y St Mus, through kindness of Winifred Goldring]. Type (x0.5). **2. Odontopleura parvula** [Minn G S 3 (2)]. Complete specimen (x3). **3–7. Encrinurus ornatus** [3, 5–7: Pal N Y 2. 4: Pal Ohio 2]. Complete specimen; tuberculate cranidium; three pygidia, the first with several thoracic segments attached. **8–10. Arctinurus** spp. **8, 10. A. boltoni.** Outline drawing of cephalon [JP 10]; cephalon [Pal N Y 2]. **9. A. nereus** [Pal N Y 2]. Incomplete specimen showing characteristic posterior median notch in pygidium. **10.** See 8 above. **11–13. Odontopleura tuberculata** [Pal N Y 3]. Incomplete specimen, cranidium, and free cheek. **14, 15. Ceratocephala goniata** [Chicago Ac Sc, B 4 (2)]. Front and side views of a complete cephalon. **16. Odontopleura callicera** [Pal N Y 7]. Nearly complete specimen (x2). **17–19. Arctinurus** spp. **17, 18. A. occidentalis** [Chicago Ac Sc, B 4 (2)]. Fragment of anterior portion of cephalon; incomplete pygidium. **19. A. boltoni** [JP 10]. Outline of pygidium from type specimen. **20, 21. Gaspelichas forillonis** [N Y St Mus, M 9]. Two views of a cranidium. **22–24. Cybeloides** spp. **22. C. lowensis** [MCZ (Harvard), B 67]. Pygidium (x3). **23, 24. C. primus** [Carnegie Mus, An 3]. Incomplete cranidium (x2) and pygidium (x4).

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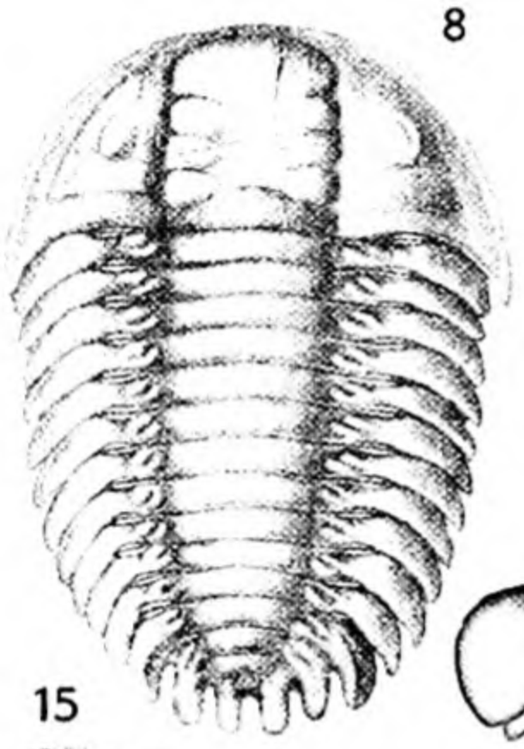

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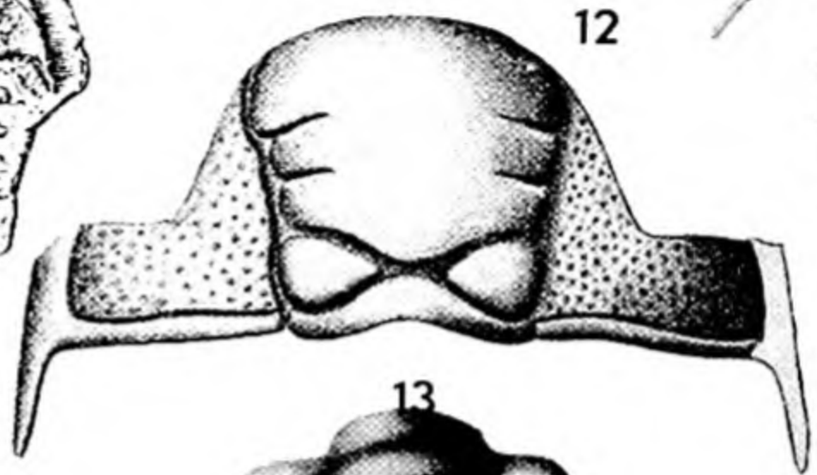

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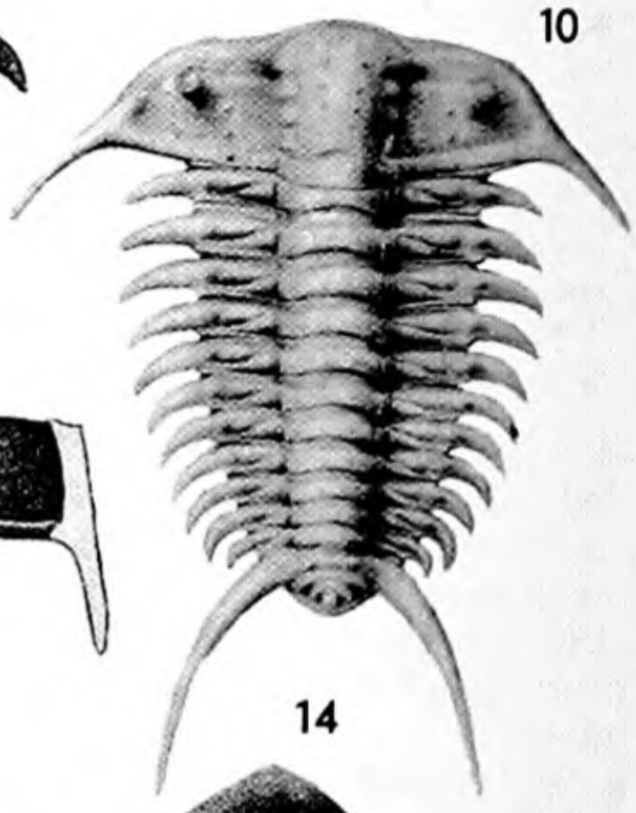

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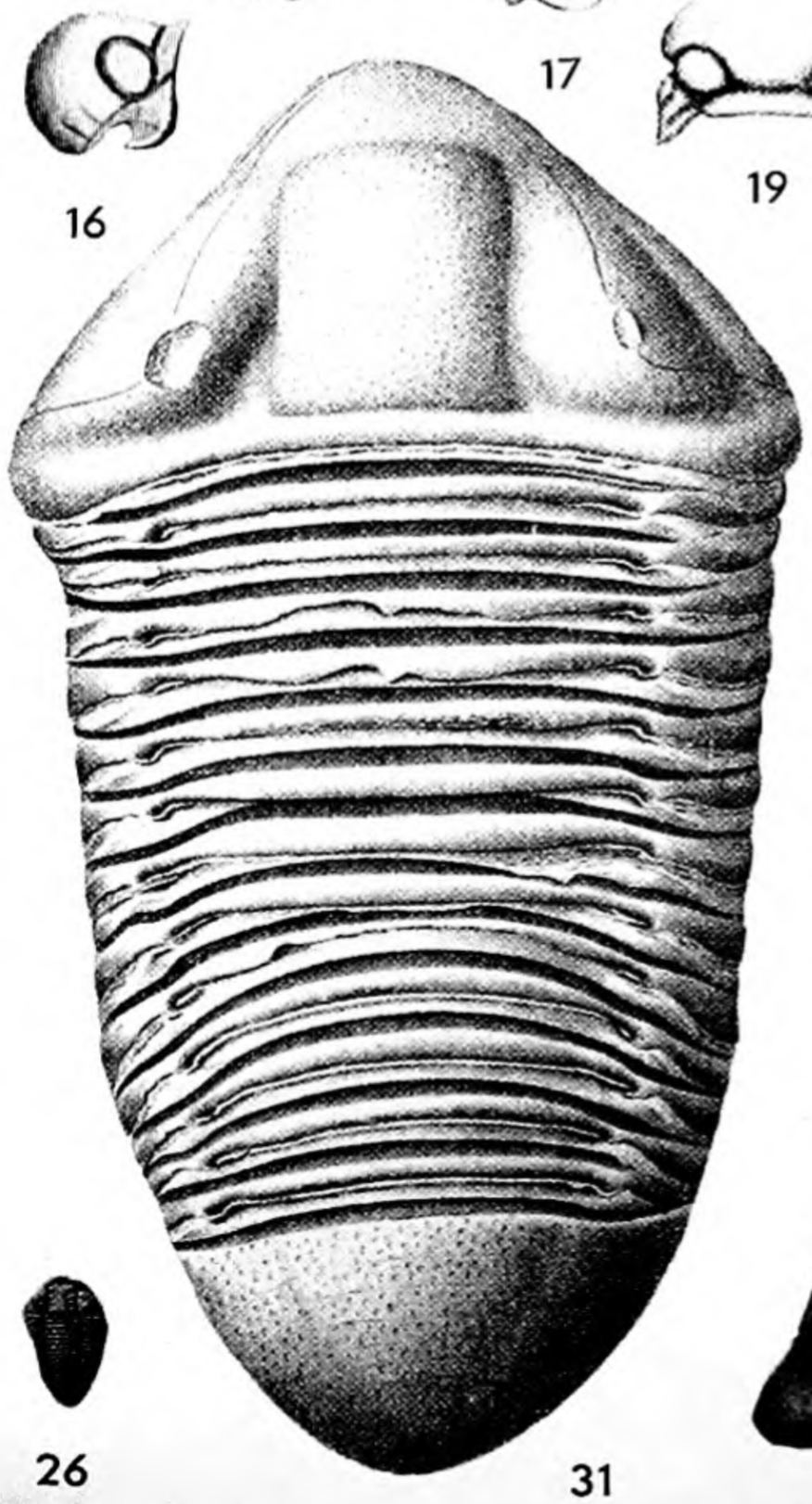

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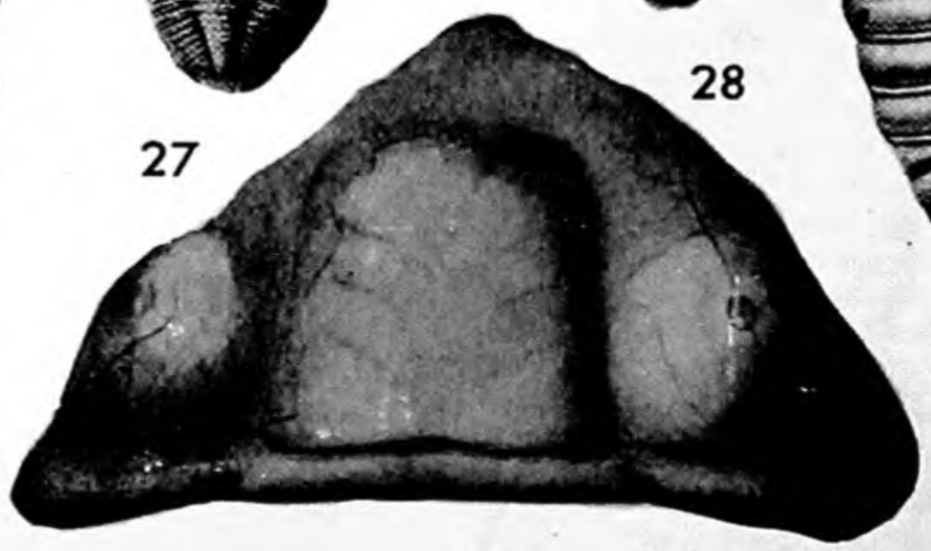

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***C. aspectans** (Conrad) (**274**—27). **Onondaga:** N. Y., Ohio, and adjacent states; ?Ill., Ind.

CRYPTOLITHUS Green 1832

(**C. tesselatus*). Cephalon trinucleate; glabella high, clavate, with one pair of pitlike furrows just in front of nuchal furrow; cheeks without ocelli in the adult; brim steeply inclined with numerous concentric rows of pits, one row in front of the girder; thorax of six short segments; pygidium short, wide, with a sharply deflected rim. **Ord.** (Que., Ont.; N. Y. to Va., Ky., Okla.; Europe).

***C. tesselatus** Green (= **Trinucleus concentricus** of earlier American authors) (**267**—2–5). Three concentric rows of pits, with strong ridges between. **Trenton:** Que. to Va.; rare in Ont. and Ky.

C. bellulus (Ulrich) (**267**—6, 7). Differs from preceding in lacking concentric ridges between rows of pits and having a flatter brim in front of glabella. **U. Trenton:** Ky.; **Eden:** N. Y., Pa., Ohio, Ky.; **Lorraine:** N. Y., Pa.

CYBELOIDES Slocom 1916

(**C. iowensis*). Glabella trilobate, with three pairs of pits in the outward curving longitudinal furrows; pygidium small, elongate, with numerous pairs of pits indicating obsolescent rings; ribs few, more or less ankylosed. **Ord.** (Newf.; Vt., N. Y., Va., Minn., Ia.).

C. primus (Raymond) (**271**—23, 24). Axial lobe with pairs of pustules; ribs distinct. **Chazyan:** Vt., N. Y.

***C. iowensis** Slocom (**271**—22). Ribs of pygidium almost obsolescent. **Maquoketa:** Ia.

CYPHASPIS Burmeister 1843

(**Phacops cerathophthalma* Goldfuss) Similar to *Proetus*, but with strongly elevated ridge surrounding glabella outside dorsal furrows; glabella with prominent basal lobes. **Ord.–Dev.** (Alaska; Man.; U. S. A.; Europe).

C. christyi Hall (**276**—11–13). Cephalon highly elevated in middle, bounded by a strongly thickened rim. **M. Sil.** (Niagaran): Ind., Tenn.

DALMANITES Barrande 1852

(**Trilobus caudatus* Brunnich). Typical dalmanitid trilobites with elongate, nondenticulate hypostoma; genal spines present; axial lobe of pygidium with 11 to 16 annulations. **Sil., L. Dev.** (N. America; Europe).

D. halli Weller (**273**—7–10). **Niagaran:** Ind. (Waldron).

D. limulurus lunatus Lambert (**273**—32). **Niagaran** (Lockport): N. Y. and adjacent states.

D. verrucosus Hall (**273**—27–29). **Niagaran:** Ind. (Waldron), Wis., Ill., Ark. (St. Claire), Mo. (Bainbridge).

D. vigilans Hall (**273**—13–16). **Niagaran:** Wis., Ill., Ind.

None of the Devonian species, which are of Helderbergian age, seems widespread enough to be diagnostic.

DALMANITINA Reed 1905

(**Dalmania socialis* Barrande). Typical dalmanitid trilobites with frontal border absent; frontal lobe not detached; hypostoma short, rounded or subquadrate; fewer than 11 pygidial annulations. **Sil.** (Niagaran or equivalent strata).

D. arkansana (Van Ingen) (**273**—18, 19). **Niagaran:** Ga. (Clinton), Wis., Ill., Ark. (St. Claire), and equivalent strata of Okla.

DIPLAPATOKEPHALUS Raymond 1937

(**Dicellocephalus finalis* Walcott). Glabella long, with a short, wide brim; the long palpebral lobes partly inclose a nearly circular posterior part of glabella, which continues forward as a tonguelike frontal lobe; posterior glabellar furrows sigmoid; pygidium short, with long, narrow axial lobe, pointed behind; margin spinose, the median spines short and feeble; ribs with slightly impressed furrows. **L. Ord.** (Vt., Nev.).

***D. finalis** (Walcott) (**267**—42, 43). Pygidium with five pairs of short spines. **L. Ord.:** Nev.

DIPLEURA Green 1832

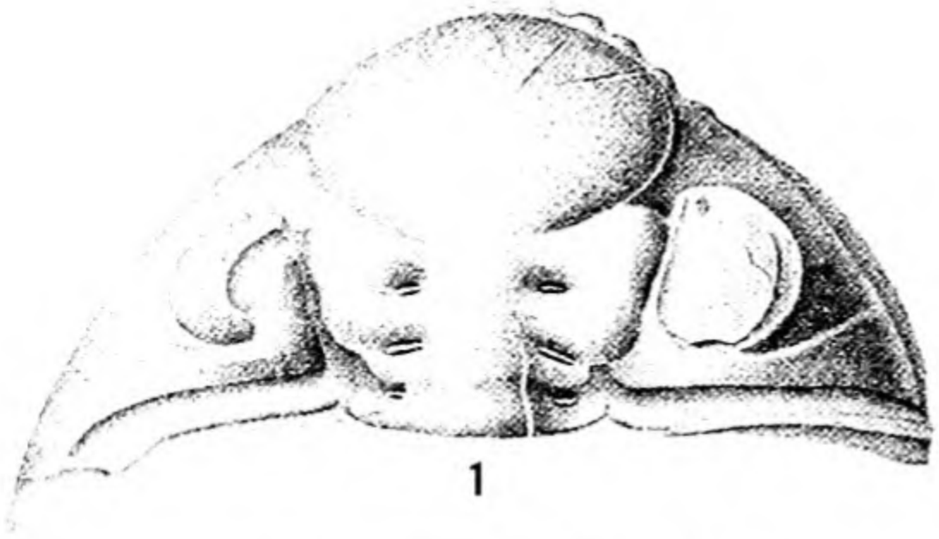
(**D. dekayi*). Differs from *Trimerus* in having more nearly parallel dorsal furrows on the cephalon and only obscure traces of segmentation in the pygidium. **Dev.** (N. America; Europe).

***D. dekayi** Green (**272**—26–31). Pygidium nearly smooth, with trilobation and segmentation obsolescent; surface of test pitted. **Hamilton:** N. Y., N. J., Pa., Md., W. Va.

PLATE 272

[Figures are x1 unless otherwise indicated.]

1–5. Flexicalymene spp. 1, 2. F. meeki [Pal Ohio 1]. Two views of an enrolled specimen. **3–5. F. senaria** [JP 15]. Lateral, posterior, and dorsal views of a cranidium (x2). **6–10. Calymene spp. 6, 7. C. celebra** [MCZ (Harvard), B 60]. Cephalon and pygidium. **8–10. C. platys** [Pal N Y 7]. Nearly complete specimen; cranidium; pygidium. **11–13. Cheirurus spp. 11, 12. C. welleri.** Specimen showing cephalon and portion of thorax [MCZ (Harvard), B 60]; pygidium [Chicago Ac Sc, B 4 (2)]. **13. C. niagarensis** [Chicago Ac Sc, B 4 (2)]. Complete cranidium. **14. Ceraurus pleurexanthemus** [MCZ (Harvard), B 54]. Drawing of complete dorsal shield. **15. Ceraurinus icarus** [Pal Ohio 1]. Complete specimen. **16–22. Sphaerexochus spp. 16. S. parvus** [Carnegie Mus, An 3]. Cranidium (x2). **17–22. S. romingeri.** 17–19: Lateral, ventral, and dorsal views of a complete cephalon [Chicago Ac Sc, B 4 (2)]. **20–22. S. romingeri** [N Y St Cab 20]. Pygidium (x2) and two views of a cranidium. **23–25. Pliomerops canadensis** [Carnegie Mus, An 3]. Anterior view of cephalon; posterior view of pygidium; dorsal view of entire specimen. **26–31. Dipleura dekayi** [26–30: JP 9. 31: Pal N Y 7]. Three different growth stages (x1, x3, x3); pygidium and cephalon (x3); typical adult specimen. **32. Trimerus vanuxemi** [Md G S, L Dev]. Incomplete cephalon. **33. Trimerus delphinocephalus** [Pal N Y 2]. Complete specimen (x0.7).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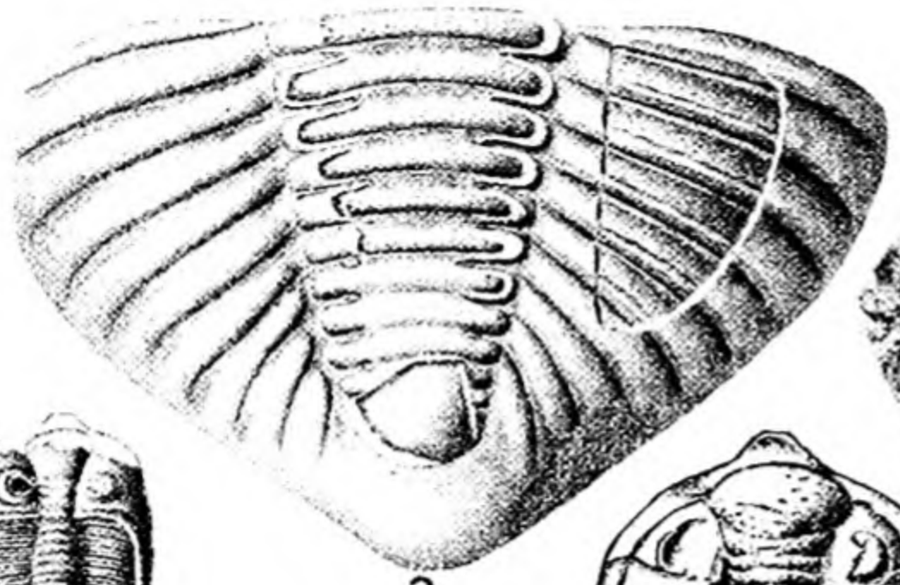
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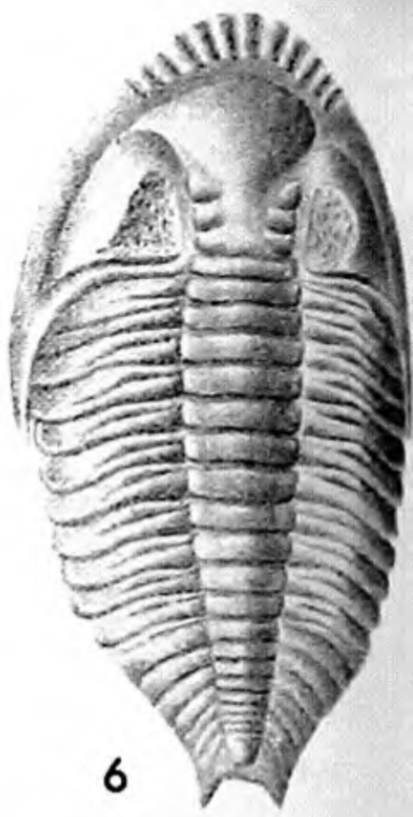
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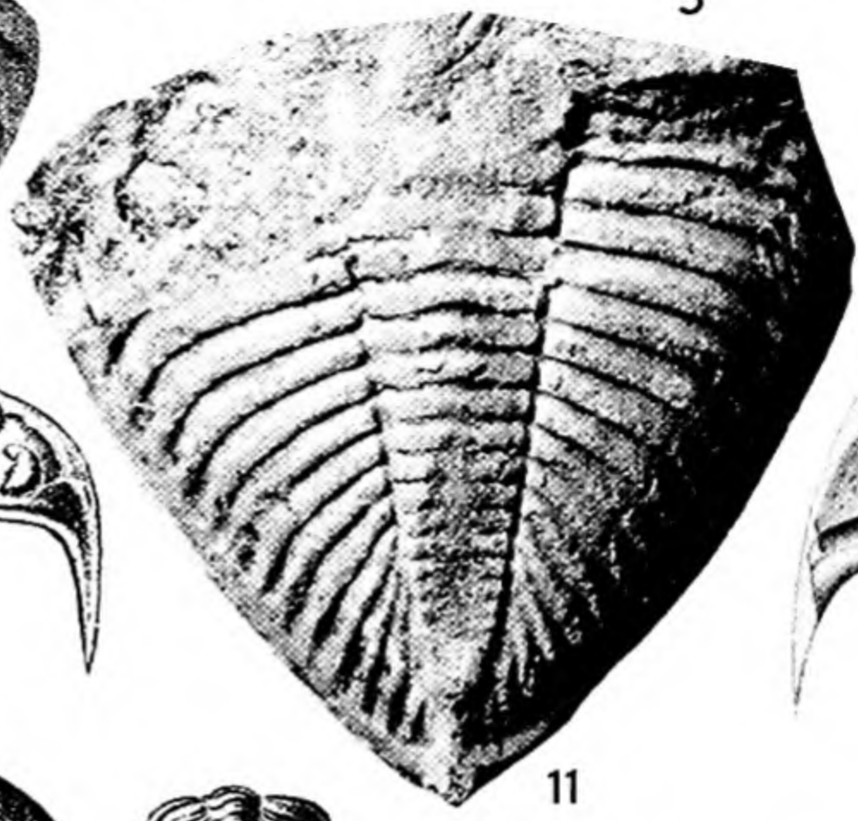
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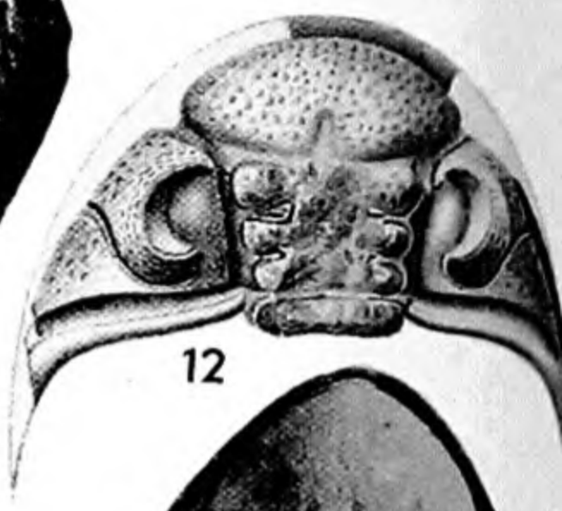
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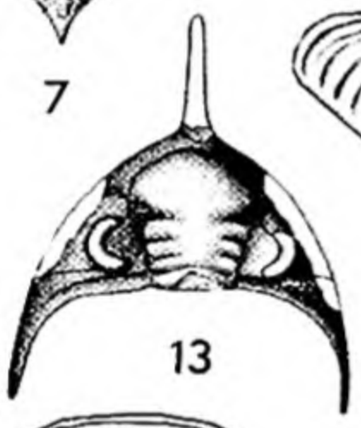
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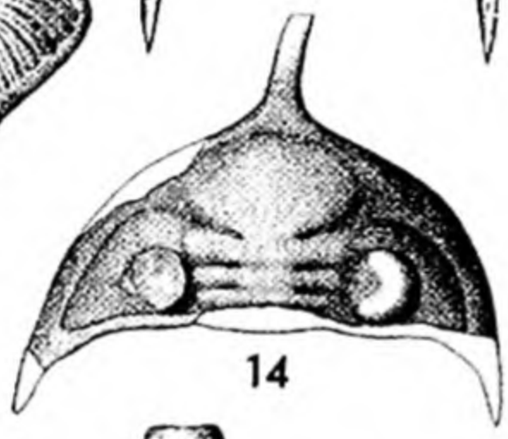
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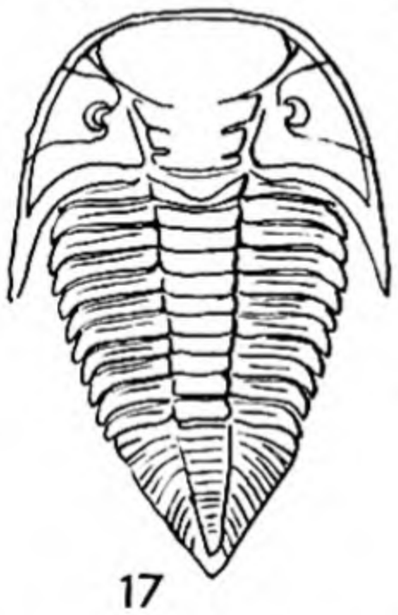
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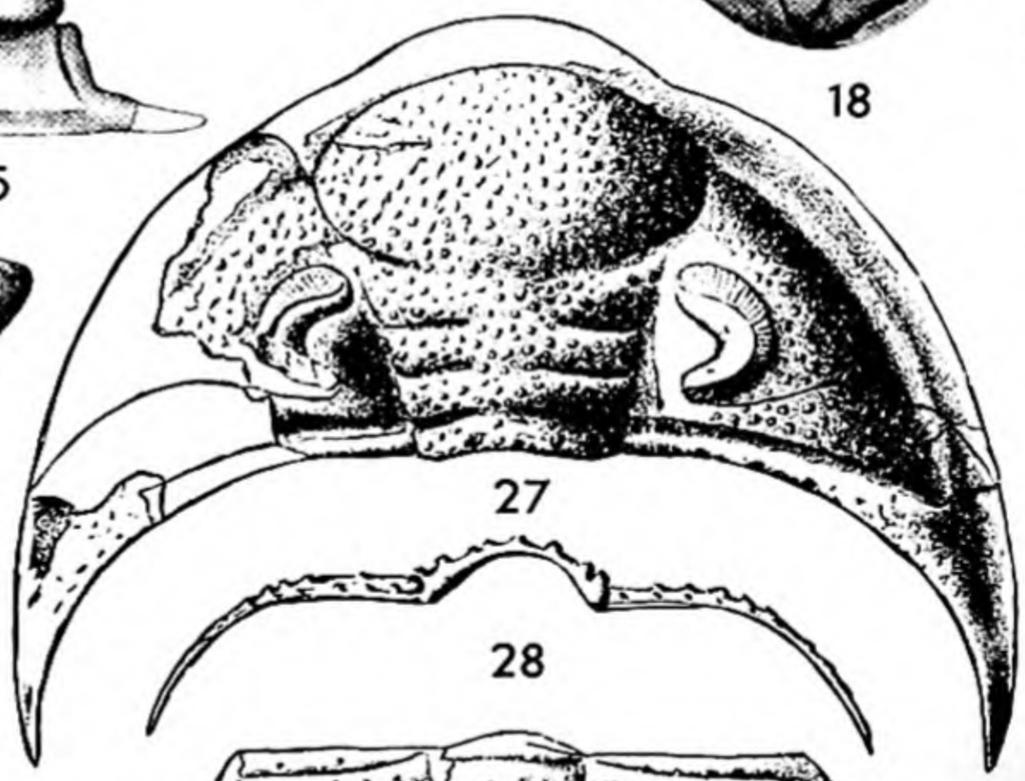
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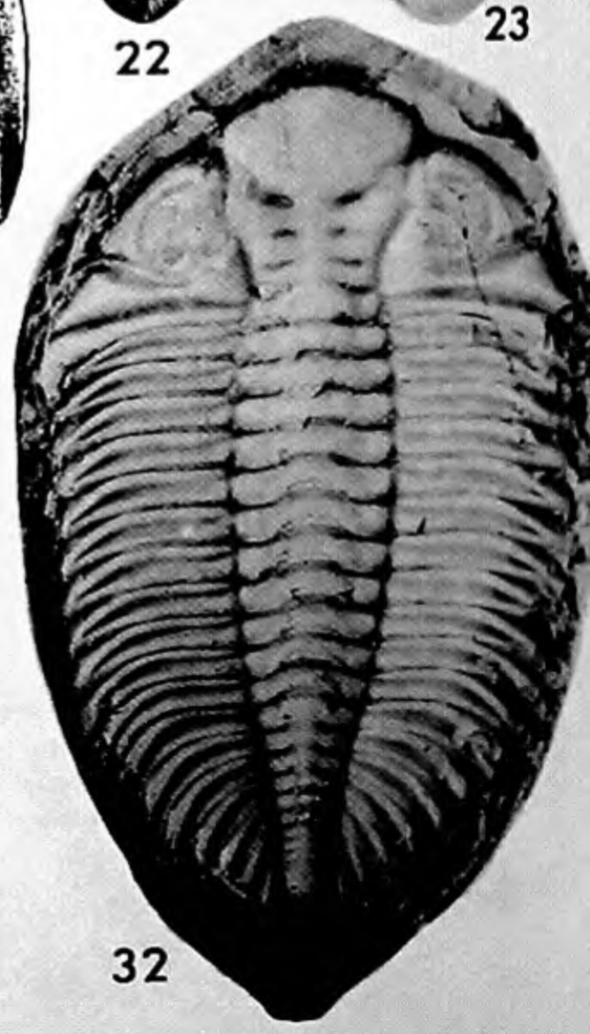
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DITOMOPYGE Newell 1931
(= CYPHINIUM Weber 1933)

(**D. lansingensis*). Cephalon without flat anterior brim; glabella expanded anteriorly; basal furrows not strongly curved; preoccipital lobe present; preoccipital furrow straight, transverse; eyes relatively large; thorax of nine segments; flange of pygidium well defined, lacking faint continuations of pleural intersegmental furrows except anteriorly; axial lobe elevated with crest commonly flattened, commonly trapezoidal in cross-section; axial segments 11 to 15, pleural 7 to 9. **Penn.–L. Perm.** (**U. Carb.** of Russia).

D. scitula (Meek and Worthen) (**275**—4–6). **Penn.:** Ind., Ill., Ark., Neb.

D. olsoni Williams (**275**—3). **L. Penn.:** Mo. (Cherokee).

D. decurtata Gheyselinck (**275**—1, 2). **Penn.:** Kan.

ECHINOLICHAS Guerich 1901

(**Lichas eriopis* Hall). Anterior glabellar lobe inflated and tuberculate; lobes quadricomposite; pygidium with three pairs of ribs ending in free points; axial lobe with two furrows and flaring posteriorly. **L.** and **M. Dev.** (N. America).

***E. eriopis** (Hall) (**270**—15, 16). **Onondaga:** N. Y.

ENCRINURUS Emmrich 1844

(**Entomostracites punctatus* Wahlenberg (*de facto*); *Trilobus punctatus* Brunnich (*de jure*)). Glabella long, expanding forward, pustulose, with three pairs of short, shallow lateral furrows; pygidium long, narrow, triangular, with numerous incomplete, more rarely complete, rings; ribs few, curved backward, more or less pustulose. **Ord., Sil.** (N. America; Europe).

E. ornatus Hall and Whitfield (**271**—3–7). Pygidium with seven pairs of ribs separated by wide furrows, and twenty incomplete rings and five pustules on the axial lobe. **M. Sil.** (Niagaran): Widespread throughout eastern and central N. America.

EOHARPES Raymond 1905

(**Harpes primus* Barrande). Cephalon with broad, flat, irregularly pitted brim, which continues backward as long, wide genal spines; glabella short; free cheeks ventral, facial sutures marginal; eyes simple, consisting of 1 to 3 ocelli at end of each eye line; hypostoma oval; thorax of 25 to 29 short, flat segments; pygidium small, wide. **Ord.** (Chazy of Champlain Valley to Va.; Trenton of Ont.; N. Y., N. J., Pa., and Minn.); **Ord.** (Europe).

***E. ottawaensis** (Billings) (**267**—1). Brim unusually broad. **Ord.:** Distribution same as for genus.

EOMONORACHUS Delo 1935

(**Dalmanites intermedius* Walcott). Frontal lobe not conspicuously alate, first and second lateral lobes more or less coalesced and offset from median portion of glabella by axial depressions; second lateral furrows complete, narrow, shallow, deeper proximally; third lobes reduced to pair of distal tubercles and low median ridge; pygidium sharply triangular, strongly convex, indistinctly bordered; narrow axial lobe extending to posterior extremity. **M. Ord.**

***E. intermedius** (Walcott) (**273**—30, 31). **M. Ord.:** Wis. (Decorah, Galena), Minn. (Decorah), Ia. (Decorah), Mo. (Auburn).

EOPHACOPS Delo 1935

(**Phacops handwerki* Weller). Small phacopids with subcranial furrows present laterally, frontal lobe not overhanging anterior cephalic margin; eyes large; cephalic doublure concave. **Sil.** (Newf.; N. America).

***E. handwerki** (Weller) (**274**—7, 8). **Niagaran:** Ind., Wis., Ill.

EXOCHOPS Weller 1936

(**Phillipsia portlocki* Meek and Worthen). Like *Griffithides* except that eyes are not covered by palpebral lobes and axial lobe of pygidium is well elevated and strongly arched transversely. **L. Miss.**

***E. portlocki** (M and W) (**276**—7). **Keokuk:** Ill., Ia., Mo.

FLEXICALYMENE Shirley 1936

(**Calymene caractaci* Salter). Glabella subparabolic to bell-shaped; dorsal furrows without constrictions; brim liplike, extended or upturned; surface papillose. **Ord., Sil.** (N. America; Europe).

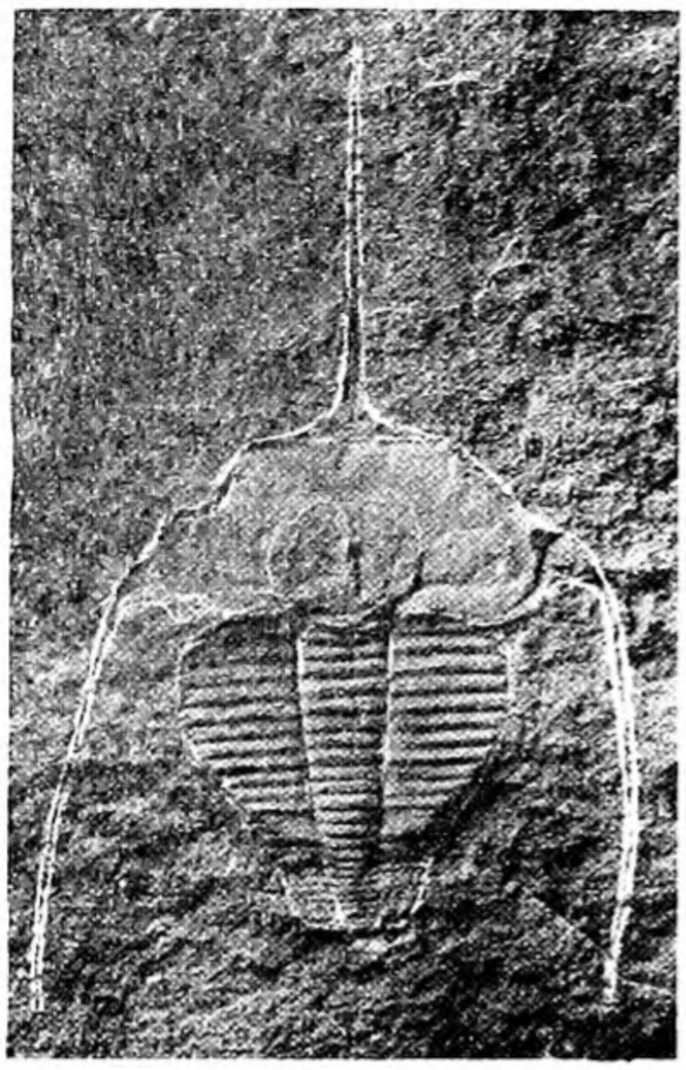
F. senaria (Conrad) (**272**—3–5). Brim narrow and shovel-shaped; pygidial ribs grooved to margin. **M. Ord.** (Trenton): Que., Ont.; N. Y. to Va., Ohio, Ill., Minn., Mo.

F. meeki (Foerste) (**272**—1, 2). Differs from preceding in having ungrooved ribs on pygidium. **U.**

PLATE 273

[Figures are x1 unless otherwise indicated; photographs furnished by Delo are indicated by DD.]

1, 2. Synphoria stemmatus [N Y St Mus, M 3]. Cephalon and pygidium. **3. Odontochile micrurus** [Pal N Y 3]. Complete dorsal shield **4–6. Odontocephalus aegeria** [Pal N Y 7]. Cephalon; pygidium; complete dorsal shield (x2). **7–10. Dalmanites halli** [Ind G S 11]. Incomplete dorsal shield; pygidium; cephalon; pygidium. **11, 12. Odontochile** spp. **11. O. micrurus** [GSA, SP 29; DD]. Pygidium (Green's holotype). **12. O. micrurus clarkei** [N Y St Mus, M 9]. Holotype cephalon. **13–16. Dalmanites vigilans** [Chicago Ac Sc, B 4 (2)]. Cephalon; cephalon viewed dorsally and laterally; pygidium. **17. Achatella achates** [Minn G S 3 (2)]. Outline of complete dorsal shield. **18, 19. Dalmanitina arkansana** [GSA, SP 29; DD]. Pygidium and cephalon. **20–23. Calliops callicephala** [20–22: Pal N Y 1. 23: GSA, SP 29; DD]. Cephalon; complete specimen; pygidium; complete specimen. **24–26. Calyptaulax glabella** [AJS (5) 20; photographs furnished by C. O. Dunbar]. Cranidium and two pygidia (x3). **27–29. Dalmanites verrucosus** [Ind G S 11]. Incomplete cephalon; a thoracic segment; pygidium. **30, 31. Eomonorachus intermedius** [GSA, SP 29; DD]. Two views of holotype. **32. Dalmanites limulurus lunatus** [GSA, SP 29; DD] Complete dorsal shield



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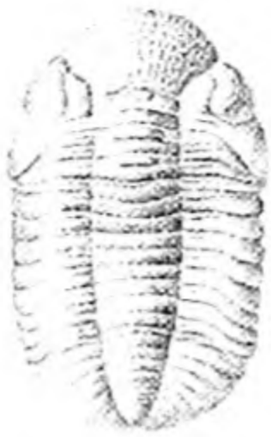

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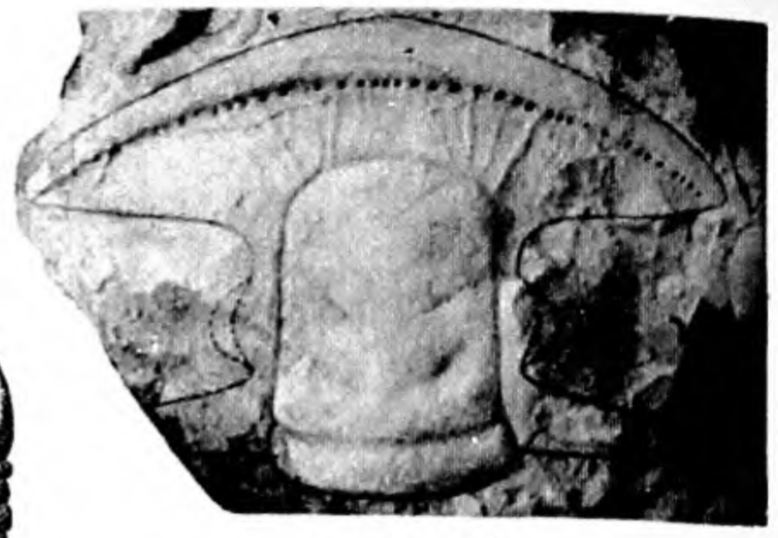

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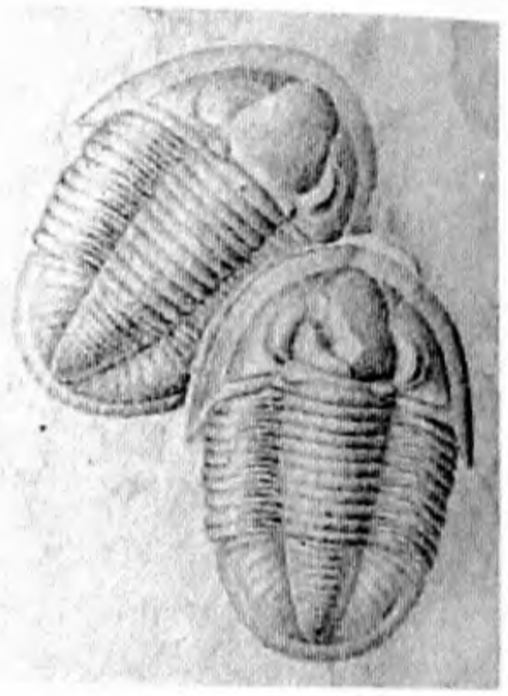

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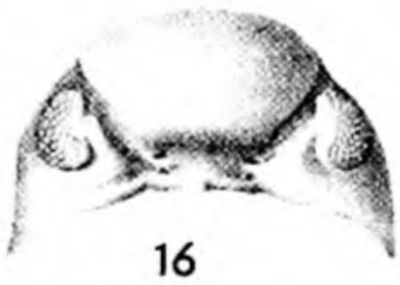

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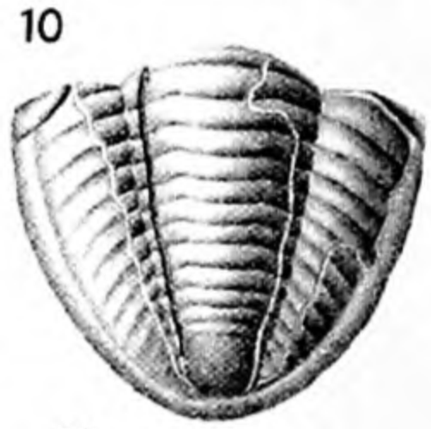

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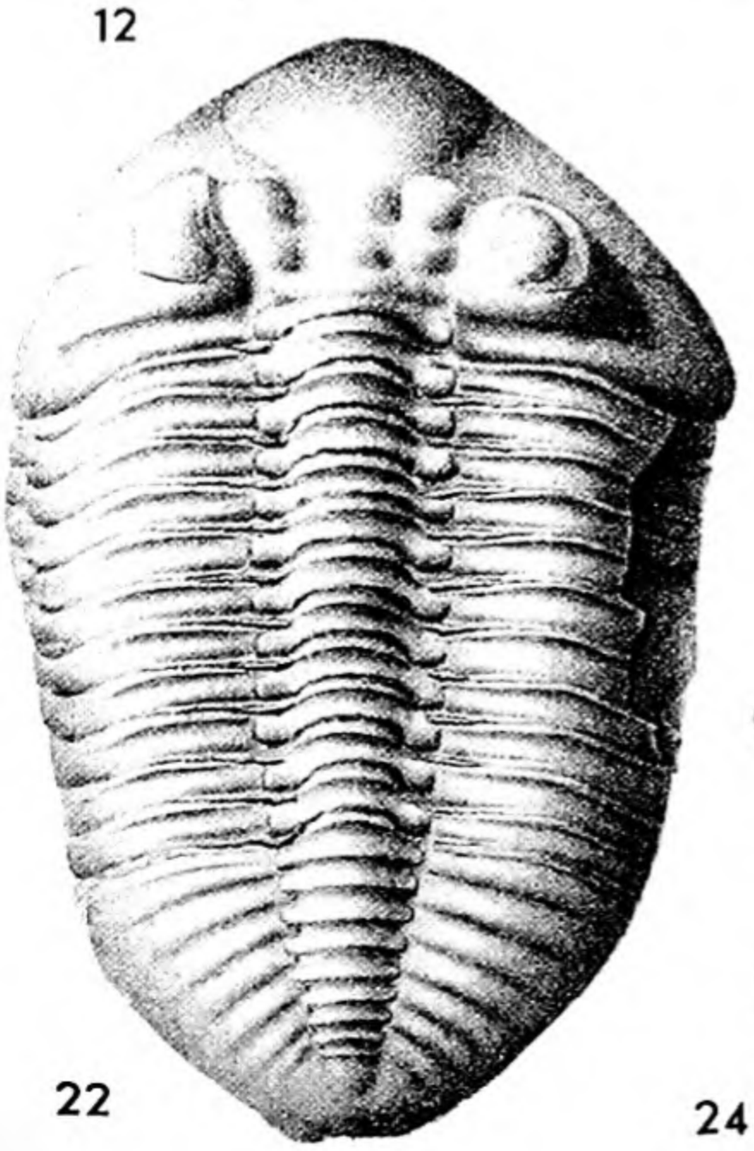

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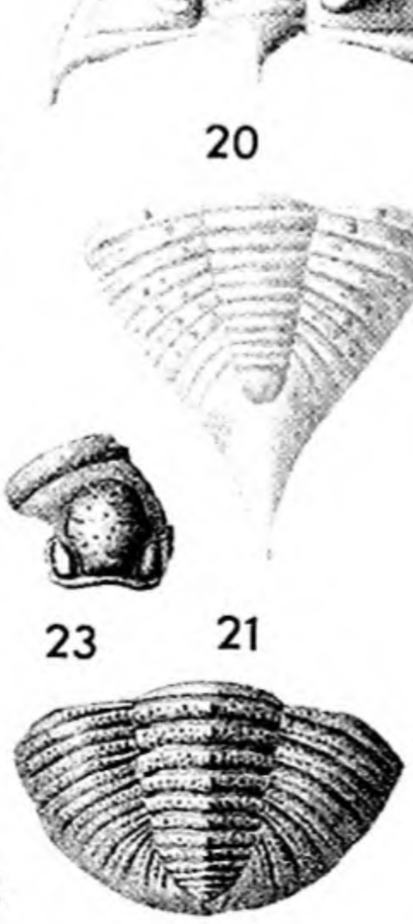

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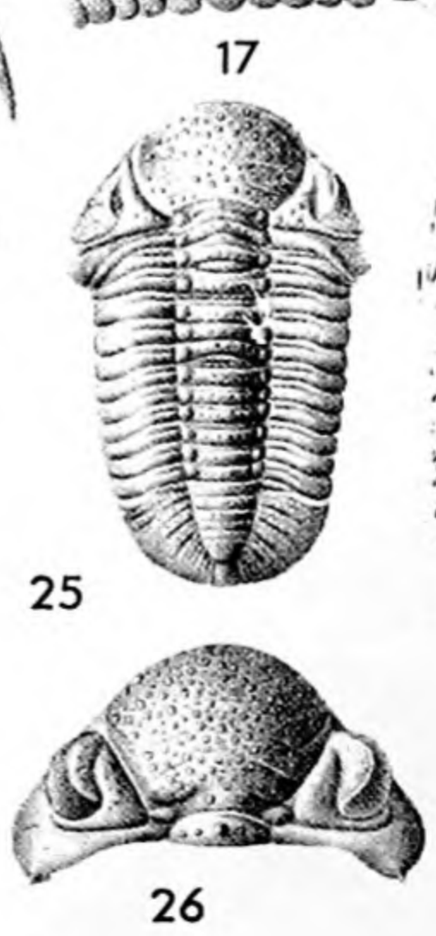

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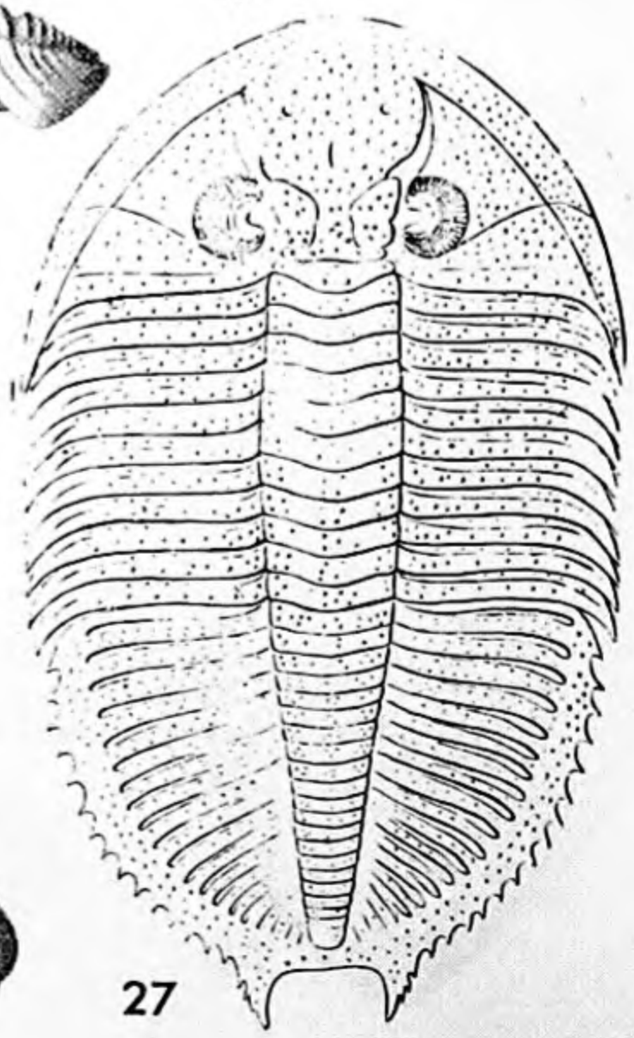

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Ord.: Que., Ont.; N. Y., Pa., and widespread throughout central N. America.

GASPELICHAS Clarke 1907

(**G. forillonia*). Cephalon elongate, inflated, spinose, and with quadricomposite lobes; occipital segment produced in spines. **L. Dev.**

***G. forillonia** Clarke (**271**—20, 21). **Oriskany:** Que. (Gaspé).

GREENOPS Delo 1935

(**Cryphaeus boothi* Green). Cephalon moderately convex with widely diverging dorsal furrows; first and second lateral lobes coalesced distally but not swollen; second lateral furrows reduced to rounded pits; third lateral lobes much reduced; third furrows short and deep, not entering dorsal furrows at their level; genal spines large; pygidial ribs wide and flat, with narrow but distinct interpleural furrows. **M.** and **U. Dev.**

***G. boothi** (Green) (**274**—11, 12). **Hamilton:** N.Y. and adjacent states.

GRIFFITHIDES Portlock 1843, emend Weller 1936

(**G. longiceps*). Cephalon without flat anterior brim; glabella expanded anteriorly; basal furrows not strongly curved; eyes small; thorax of nine segments; pygidium like *Phillipsia*, but with 13 to 16 axial segments and 10 to 12 pleural segments. **Miss.** (N. America; Europe).

G. bufo (Meek and Worthen) (**275**—9). **Miss.:** Ind. (Keokuk).

G. pustulosus Snider (**275**—10–12). **Chester:** Okla. (Mayes).

HOMOTELUS Raymond 1920

(**H. ulrichi*). Similar to *Isotelus*, but without concave brims on cephalon or pygidium. **M** and **U. Ord.** (N. America).

H. obtusus (Hall) (**268**—6, 7). Test conspicuously punctate. **Chazyan:** Champlain Valley; Va.

***H. ulrichi** Raymond (**268**—8). Test not conspicuously punctate. **Eden:** Cincinnati area, Ohio.

HYSTRICURUS Raymond 1913

(**Bathyurus conicus* Billings). Glabella short, convex, tapering toward front; eyes small, eye lines absent; free cheeks small and widely separated in front; pygidium short, of few segments. **L. Ord.** (Greenland; Newf.; widespread throughout N. America).

***H. conicus** (Billings) (**267**—27). **L. Ord.:** Greenland; Newf.; Champlain Valley; Mo., Nev.

H. missouriensis Ulrich (**267**—28, 29). **Gasconade:** Mo.

ILLAENUS Dalman 1827

(**Entomostracites crassicauda* Wahlenberg). Isopygous; axial lobe about one-third total width; cephalon and pygidium short and wide, without brims; dorsal furrows extend only a short distance on cephalon; glabellar and nuchal furrows absent; eyes small, far back; thorax of 8 to 10 segments; pygidium short, without ribs, and with short smooth axial lobe, not limited behind. **Ord., Sil.** (N. America; Europe).

I. americanus Billings (**268**—16–18). Cephalon short, abruptly incurved; eyes small and far apart. **M. Ord.:** Ont.; N. Y., Pa., Wis., Minn.

ISOTELOIDES Raymond 1910

(**Asaphus canalis* Whitfield). Differs from *Isotelus* in having glabella definitely outlined by dorsal furrows, more obvious segmentation on pygidium, and narrower axial lobe in thorax. **Ord.** (N. America).

***I. canalis** (Whitfield) (**268**—9, 10). Cephalon with nearly rectangular, faintly defined glabella and moderate genal spines; pygidium with comparatively narrow, well defined axis. **Beekmantown:** Vt., N. Y.

ISOTELUS Dekay 1824

(**I. gigas*). Isopygous; cephalon and pygidium smooth, with brims that lack rims; hypostoma bifurcated; axial lobe of thorax wide. **Ord.** (N. America; Norway).

***I. gigas** Dekay (**268**—2, 3). Cephalon and pygidium elongate, the former without genal spines in the adult. **M. Ord.:** Widespread throughout N. America.

I. iowensis Owen (**268**—1). Similar to preceding but with genal spines. **Maquoketa:** Minn., Ia.

I. brachycephalus Foerste (**268**—19). Differs from *I. gigas* in having genal spines and wide, rounded, instead of subtriangular, shields. **Richmond:** Ohio.

KAINELLA Walcott 1925

(**Hungaia billingsi*). Cranidium wide at front as

PLATE 274

[Figures are x1 unless otherwise indicated; photographs furnished by Delo are indicated by DD.]

1. Alsataspis evansi [Can Field Nat 56 (3)]. Complete specimen with spines outlined. **2–5. Phacops rana.** 2, 3: Side and dorsal views of complete dorsal shield [Pal N Y 7]. 4: Holotype [GSA, SP 29; DD]. 5: A very large complete specimen (x0.5) [Pal N Y 7]. **6. Proetus haldemani** [Pal N Y 7]. Original specimen (x2). **7, 8. Eophacops handwerki** [Chicago Ac Sc, B 4 (2)]. Complete specimen, and a cephalon. **9. Kainella billingsi** [SMC 75 (3)]. Large cranidium with outlines restored. **10. Proetus rowi** [Pal N Y 7]. Two well preserved dorsal shields of average size. **11, 12. Greenops boothi** [Pal N Y 7]. An entire specimen of average adult proportions; a large pygidium. **13. Acaste downingiae** [USGS, Fol 192]. **14, 15. Reedops deckeri** [GSA, SP 29; DD]. Typical specimen, enrolled; holotype pygidium. **16, 17. Phacops cristata** [Pal N Y 7]. Cephalon and side view of portion of thorax and pygidium. **18, 19. Proetus crassimarginatus.** A large elongate pygidium [Pal N Y 7]; a broad pygidium (x2) [GSA, B 46]. **20–22. Anchiopsis anchiops** [Pal N Y 7]. A small cephalon; a small pygidium (x2); a nearly complete dorsal shield, the type. **23, 24. Cordania becraftensis** [N Y St Mus, M 3]. Fragmental cranidium; complete pygidium (x3). **25, 26. Phacops logani** [Pal N Y 7]. Entire specimen, the type; a complete cephalon (x2). **27. Coronura aspectans** [N Y St Mus, Rp 44; GSA, SP 29; DD]. Complete dorsal shield.

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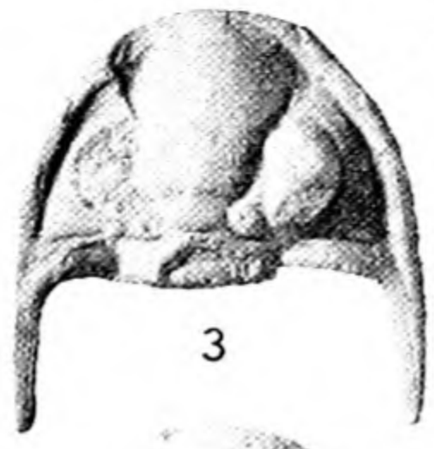

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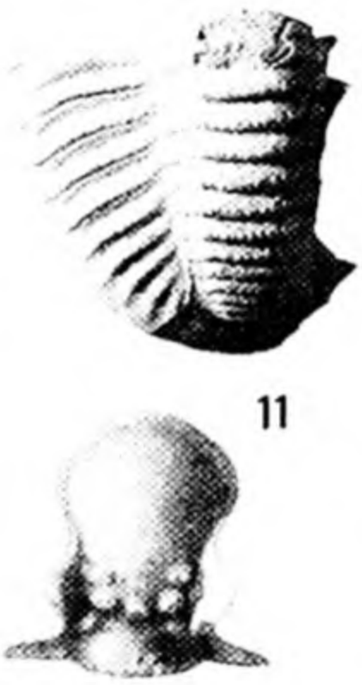

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sutures turn abruptly outward in front of eyes; glabella with two pairs of furrows which do not reach the dorsal ones, the posterior pair confluent; brim wide, with radial markings; intramarginal furrow with row of deep pits; pygidium with two pairs of ribs which turn back parallel to the axis and end in convergent spines. **Canadian** (Cordilleran areas of Canada and U. S. A.; Argentina).

***K. billingsi** (Walcott) (**274**—9). **Cushina:** B. C.

KASKIA Weller 1936

(**K. chesterensis* S. Weller and J. M. Weller). Cephalon with flat anterior brim absent or obsolete in mature specimens; glabella expanded anteriorly; basal furrows not strongly curved; preoccipital lobe absent; eyes large; thorax of nine segments; flange of pygidium well defined, lacking faint continuations of intersegmental furrows except anteriorly; axial lobe elevated, subtrapezoidal in cross-section, crest gently arched transversely; axial segments 13 to 17, pleural 8 to 12. **M.** and **U. Miss.**

***K. chesterensis** W and W (**275**—29–33). **Chester:** Pa. ("Maxville"), Ky., Ill., Okla. (Pitkin, Mayes).

KERAKEPHALICHAS Phleger 1936

(**Amphilichas rhinoceras* Slocom) Glabella differs from *Tetralichas* in supporting one or more pairs of hornlike processes. **U. Ord.**

***K. rhinoceras** (Slocom) (**270**—5). **Maquoketa:** Ia.

K. bicornis (Ulrich) (**270**—11, 12). **Maquoketa:** Minn.

LEIOSTEGIUM Raymond 1913

(**Bathyurus quadratus* Billings). Elongate oval and isopygous; glabella quadrate, outlined by deep, narrow furrows, and extending to narrow elevated anterior rim; fixed cheeks wide; eyes small and far from glabella; nine thoracic segments; pygidium unsegmented, with axial lobe elevated and extending nearly whole length, and no concave border. **L. Ord.** (N. America; Argentina).

***L. quadratum** (Billings) (**267**—16). **Beekmantown:** Que.

L. puteatum Raymond (**267**—20–22). **Highgate:** Vt.

LICHAS Dalman 1827

(**Entomostracites laciniatus* Wahlenberg). Bicomposite and basal glabellar lobes; longitudinal furrows end in notches at third glabellar furrows; anterior two pairs of pygidial ribs end in free points; axial lobe with two furrows, flaring posteriorly. **M.** and **U. Ord.** (Europe), **M. Sil.** (N. America).

L. ferrisi (Weller) (**270**—17, 18). **Niagaran:** Ill.

LONCHODOMAS Angelin 1854

(**Ampyx rostratus* Sars). Cephalon subtriangular, without brim; glabella high, narrow, extended anteriorly into a long prismatic spine; genal spines slender; thorax of five short segments; pygidium short, wide, similar to that of *Cryptolithus*, but without the raised girder where deflected at back and sides. **Ord.** (N. America; Europe).

L. halli (Billings) (**267**—10–13). Glabella rather sharply carinated along its top, and extending half its length beyond the anterior margin of the fixed cheeks, beyond which it is prolonged as a prismatic spine with a furrow on each of its four sides; pygidium very broadly triangular, its flat border abruptly bending downward at nearly a right angle. **Ord.** (Chazy): Que.; Vt., N. Y. to Md.

L. normalis (Billings) (**267**—14, 15). Differs from preceding in having fixed cheeks extending to base of rostrum. **Ord.:** Chazy of Newf.; Black River of Pa. and Md.

NILEUS Dalman 1827

(**Asaphus* (*Nileus*) *armadillo*). Similar to *Bumastus*, the eyes proportionately larger, crescent-shaped, and placed farther forward, with a median pustule between them; dorsal furrows turn outward and join a marginal depression in front of eyes; thorax distinctly trilobate, composed of seven or eight segments. **L.** and **M. Ord.** (eastern N. America; northern Europe).

N. scrutator Billings (**267**—34, 35). **Chazyan:** Newf.; Que., Va. (Holston), Tenn. (Athens).

ODONTOCEPHALUS Conrad 1840

(**Asaphus selenourus* Eaton). Like *Synphoria*, except that cephalic border has distally coalesced spines in front of glabella, and pygidium has a crescentic terminus of two spines. **M. Dev.**

O. aegeria Hall (**273**—4–6). **Onondaga:** N. Y.; **Grand Tower:** Ill., Mo.; **Jeffersonville:** Falls of Ohio.

ODONTOCHILE Hawle and Corda 1847

(**Asaphus hausmanni* Brongniart). Like *Dalmanites*, except that hypostoma is denticulate and pygidial annulations number 16 to 22. **L. Dev.**

PLATE 275

[Photographs were made from negatives loaned by J. M. Weller unless otherwise indicated.]

1–6. Ditomopyge spp. (x4). **1, 2. D. decurtata.** Cephalic and pygidial views of a complete specimen. **3. D. olsoni.** Cephalon. **4–6. D. scitula.** Cephalic and side views of an enrolled specimen; pygidium. **7, 8. Paladin morrowensis** (x4). Incomplete cephalon, the type; pygidium. **9–12. Griffithides** spp. **9. G. bufo** (x1.5). An almost complete specimen. **10–12. G. pustulosus** (x2). Incomplete cranidium and pygidium; free cheek. **13–18. Brachymetopus** spp. **13–15. B. armatus** (x1) [U Mo Stud 13]. A spinose pygidium; pygidium with spines broken off; free cheek. **16–18. B spinosus** (x2) [DUB, JSL 4]. Incomplete cranidium; top and side views of pygidium. **19–22. Anisopyge perannulata** (x1) [USGS, PP 58]. Free cheek; cranidium; top and side views of a typical pygidium showing large number of segments in axial lobe. **23–27. Ameura** spp. **23, 24. A. major** (x1.5). Cephalic and pygidial views of a complete specimen. **25–27. A. sangamonensis** (x2). Side, cephalic, and pygidial views of a complete specimen. **28. Brachymetopus lodiensis** (x2) [Ohio G S 2]. Drawing of a gutta-percha replica. **29–33. Kaskia chesterensis** (x4) [JP 10]. Pygidium; free cheek; anteroposterior, cephalic, and pygidial views of holotype.

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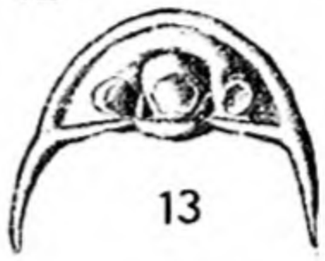

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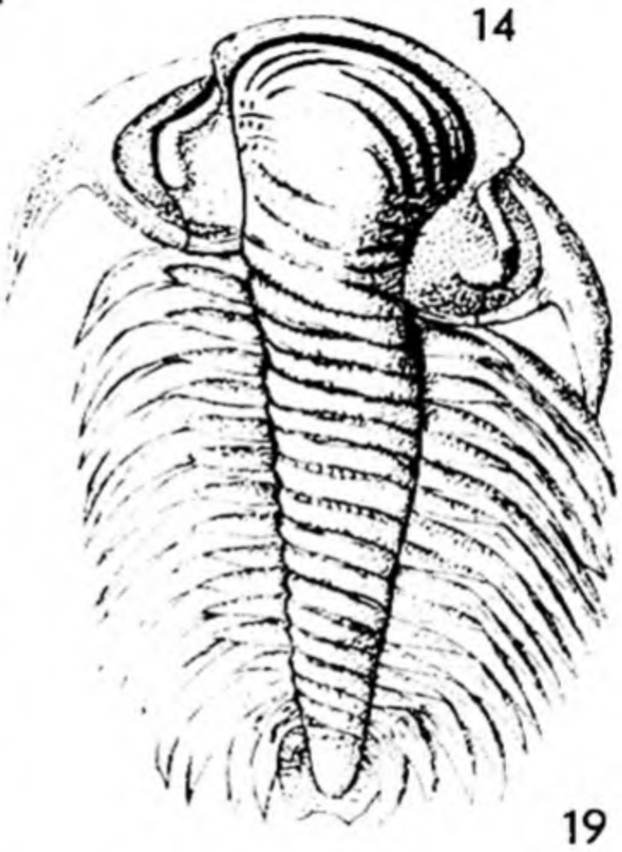

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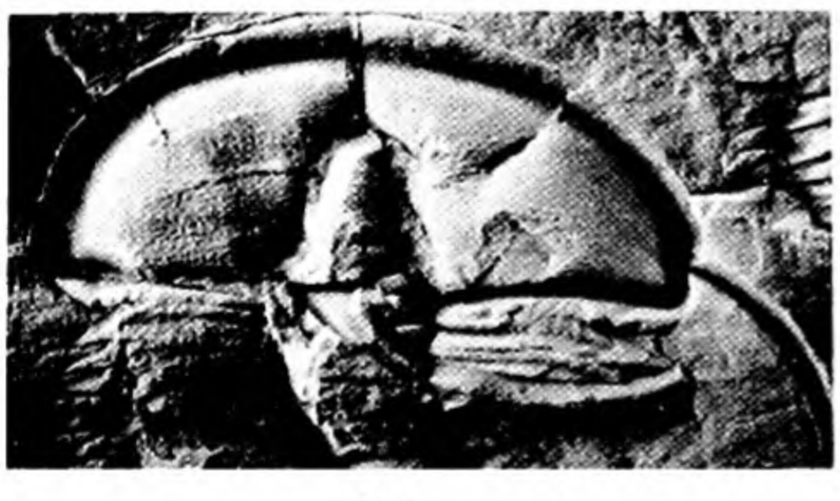

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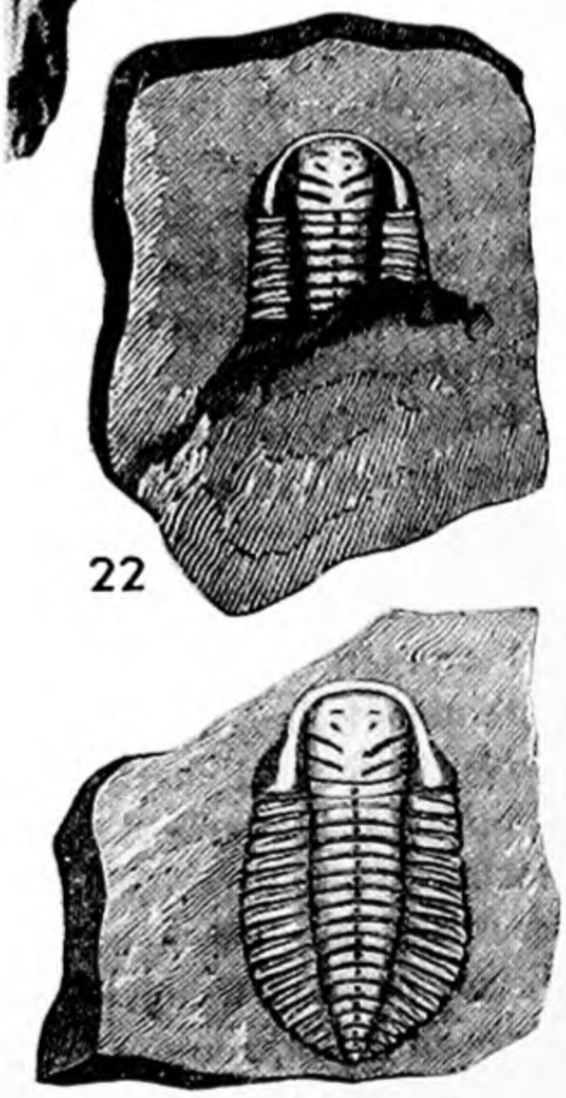

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O. micrurus (Green) (**273**—3, 11). **Helderbergian:** Ont.; N. Y. to Md., Miss.

O. micrurus clarkei Delo (**273**—12). **L. Dev.:** Gaspé, Que.

ODONTOPLEURA Emmrich 1839

(= ACIDASPIS (*partim*) of American authors; LEONASPIS (*partim*) of Richter)

(*O. ovata*). Glabella with two or three pairs of lateral lobes; no fourth lobes, and no post-central lobe or process; nuchal ring without spines; pygidium small, with several pairs of marginal spines. **Ord., Sil.** (N. America; Europe).

O. parvula Walcott (**271**—2). Test small; entire surface highly tuberculate. **Trenton:** N. Y., N. J., Minn.

O. tuberculata (Conrad) (**271**—11–13). Glabellar lobes oval; a short nuchal spine present. **Helderbergian:** N. Y.

O.? callicera (Hall and Clarke) (**271**—16). Cranidium depressed below level of cheeks; two pairs of glabellar lobes, separated from high central lobe by furrows; nuchal spine small. **Onondaga**: Ont.; N. Y., Pa., Va., W. Va.

PALADIN Weller 1936

(**Griffithides morrowensis* Mather). Cephalon like *Phillipsia*, *Griffithides* and *Exochops* except that eyes are large; flange of pygidium distinct, not bearing faint continuations of intersegmental pleural furrows except anteriorly; axial segments 14 to 16, pleural 9 to 10. **U. Miss., L. Penn.** (N. America).

***P. morrowensis** (Mather) (**275**—7, 8). **L. Penn.:** Ark. (Morrow).

PHACOPS Emmrich 1839

(**P. latifrons* Bronn). Glabella more or less swollen; subcranial furrow continuous; genal angles generally rounded; marginal rim narrow; cephalic doublure slightly convex. **Sil., Dev.** (one **Sil.** species in N. America, remainder **Dev.**).

P. logani Hall (**274**—25, 26). **L. Dev.** (Helderbergian): Widespread throughout N. America.

P. cristata Hall (**274**—16, 17). **Dev.** (Oriskany, Schoharie, Onondaga): Ont.; N. Y. and adjacent states, Ohio, Ind., Mo.?

P. rana Green (**274**—2–5). **Dev.** (Hamilton; type probably from Moscow): Ont.; N. Y. and adjacent states; central U. S. A.

PHILLIPSIA Portlock 1843

(**Asaphus gemmuliferus* Phillips). Cephalon with flat anterior brim; glabella not expanded in front, sides nearly parallel and straight; widest posteriorly at basal lobes; basal furrows strongly curved; eyes small; thorax of nine segments; flange of pygidium not well defined; segmentation of pleural lobes extending almost to margin; axial lobe of pygidium low, nearly uniformly arched transversely. **L. Miss.** (N. America; Europe).

P. swallowi (Shumard) (**276**—4–6). **Chouteau:** Mo.

P. sampsoni Vogdes (**276**—1–3). **Bushberg:** Mo.

PLIOMEROPS Raymond 1905

(= PLIOMERA Raymond 1905, not PLIOMERA Angelin 1854)

(**Amphion canadensis* Billings). Cephalon broad, short, with a distinct marginal rim; glabella moderately elevated, with parallel sides; free cheeks small; thorax with 15 to 19 segments, with inflated pleura; pygidium hemispheric, smaller than cephalon. (In the European *Pliomerops* the glabella expands anteriorly and has two small median lobes on its front.) **M. Ord.** (Newf.; N. America; Ireland).

***P. canadensis** (Billings) (**272**—23–25). Spines of pygidium wide and close together and so curved that all point directly posteriorly. **Chazyan:** Mingan Islands, Que., Ont.; Vt., N. Y., Tenn. (Lenoir).

PROETUS Steininger 1831

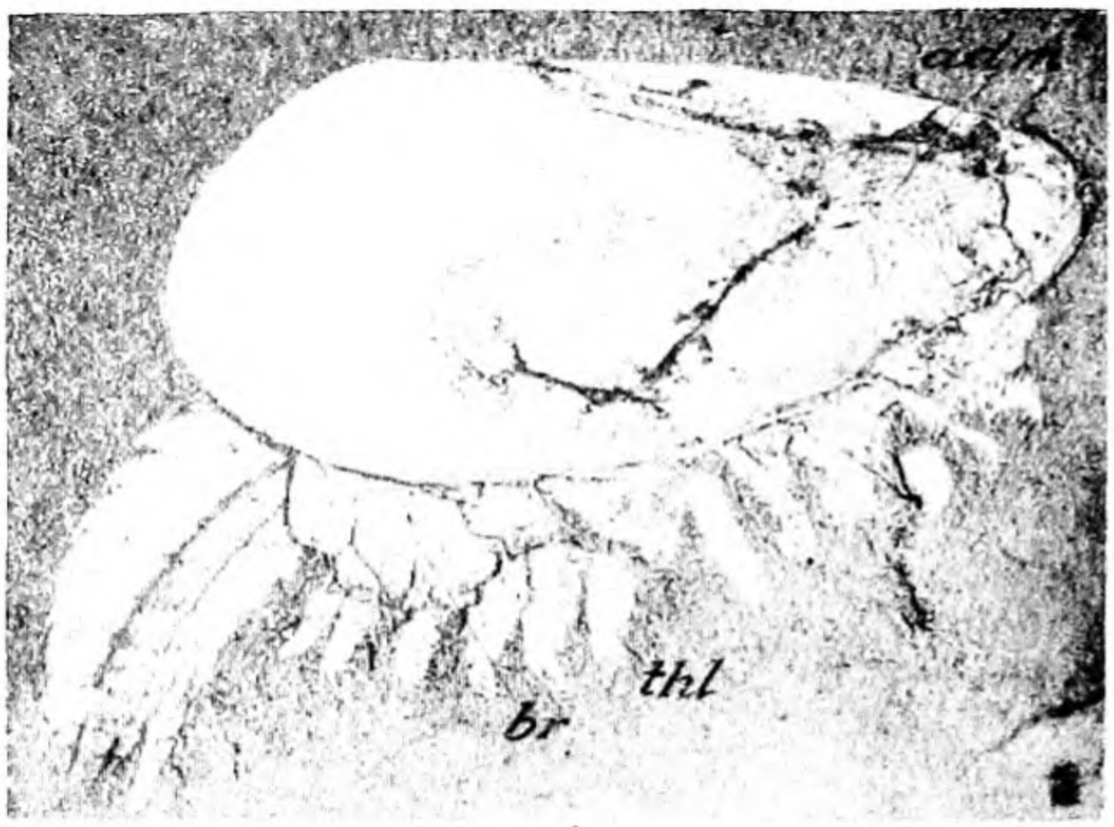
(**Calymene concinna* Dalman). Cephalon somewhat larger than pygidium; glabella convex, extending nearly to anterior cephalic margin, and without deep lateral furrows; eyes prominent, smooth, and close to glabella; thoracic segments usually 10, convex, with pleura grooved; pygidium semicircular with flat margin, its axis very convex and not extending to posterior border, and usually with less than 14 annulations; entire test surface granulose. **Ord.–Miss.** (N. America; Europe).

P. crassimarginatus Hall (**274**—18, 19). Genal spines broad and flat; glabella large, very convex, subquadrate; no external evidence of glabellar furrows; occipital ring broad upon axis, narrowing upon cheeks; pygidium equally trilobate. **L. Dev.:** Ont.; N. Y., Mich., Ohio, Ind., Ky., Wis., Ill., Ia., Mo.; Alaska.

PLATE 276

[Figures are x1 unless otherwise indicated; figures 17–21, 24–26 were furnished by B. F. Howell.]

1–6. Phillipsia spp. [U Mo Stud 13]. **1–3. P. sampsoni.** Entire dorsal shield with pustulose surface; a nearly complete shield with pustulose surface exfoliated; pygidium. **4–6. P. swallowi** (x2). Incomplete cephalon; pygidium; incomplete dorsal shield. **7. Exochops portlocki** (x4) [JP 10]. Left half of cephalon. **8–10. Proetus** spp. **8. P. nevadae** [photograph from negative furnished by G. A. Cooper]. Complete dorsal shield. **9, 10. P. missouriensis** [Mo G S, An Rp 1, 2]. Cranidium and pygidium. **11–13. Cyphaspis christyi** (x2) [Ind G S 11]. Complete specimen viewed dorsally and laterally; cephalon. **14–16. Sevillia sevillensis** (x4) [JP 10]. Side and dorsal views of incomplete pygidium; dorsal view of cephalon. **17, 18. Condylopyge rex** (x9) (also see **251**—23, 24). Pygidium; cephalon, lighted from upper right. **19. Paradoxides lamellatus** [R Soc Can, Tr 8] (also see **254**—14, 15). A distorted specimen. **20, 21. Bailiella** spp. (also see **253**—10–12). **20. B. venulosa** (x4). Cephalon with some thoracic segments attached. **21. B. baileyi** (x2). Incomplete cephalon. **22, 23. Triarthrus** spp. [AJS 33] (also see **252**—17, 18). **22. T. beckii. 23. T. eatoni. 24. Peltura scarabaides** (also see **262**—16, 17). Impression of a large specimen and dorsal view of a smaller. **25, 26. Andrarina** spp. (see **259**—12, 13). **25. A. tenera** (x4). A large cranidium concealing most of a smaller one. **26. A. ouangondiana** (x3.5). Incomplete cranidium.



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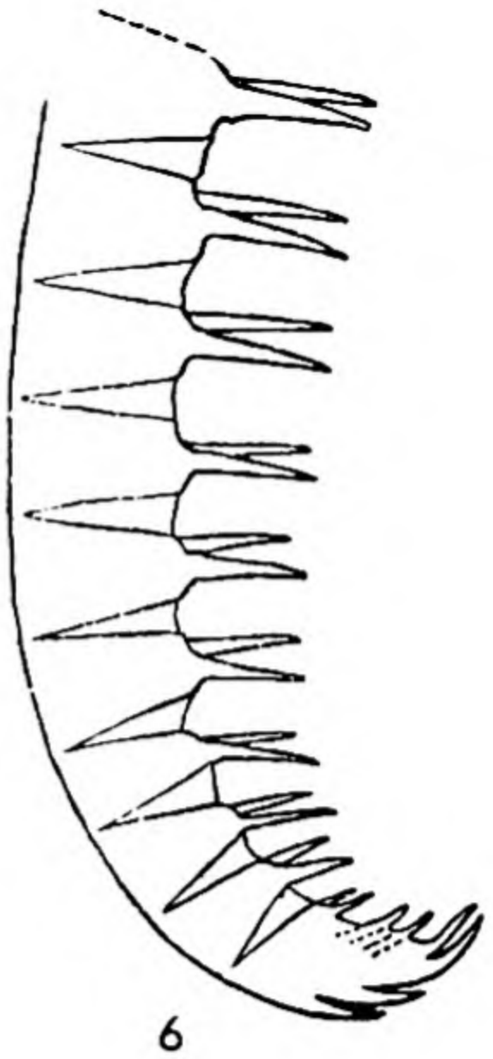

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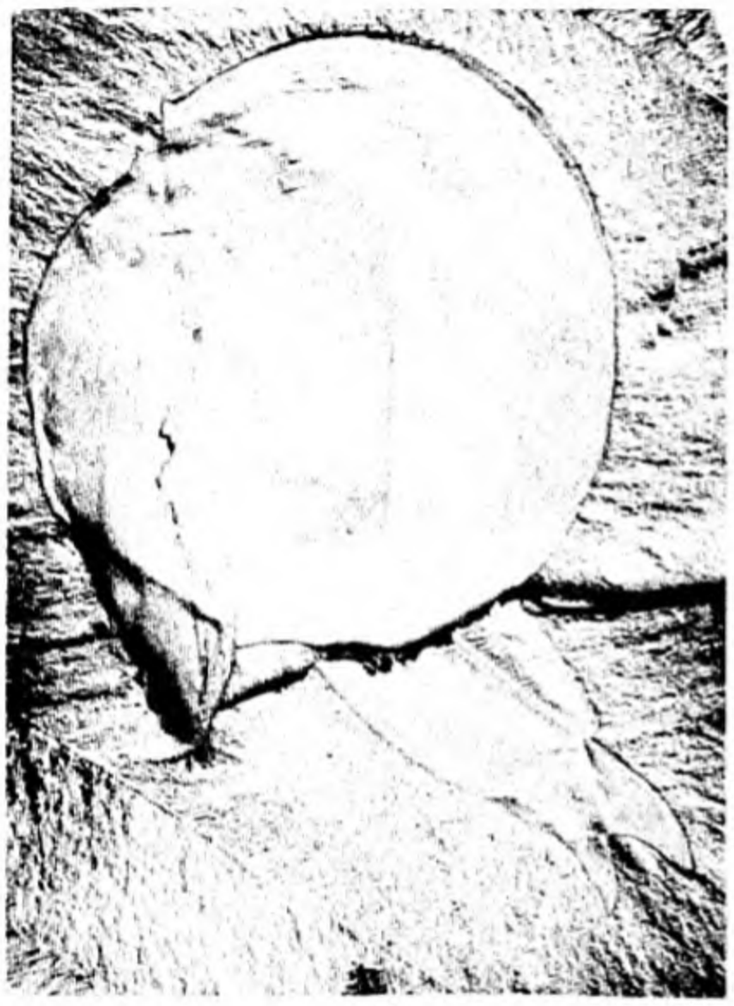

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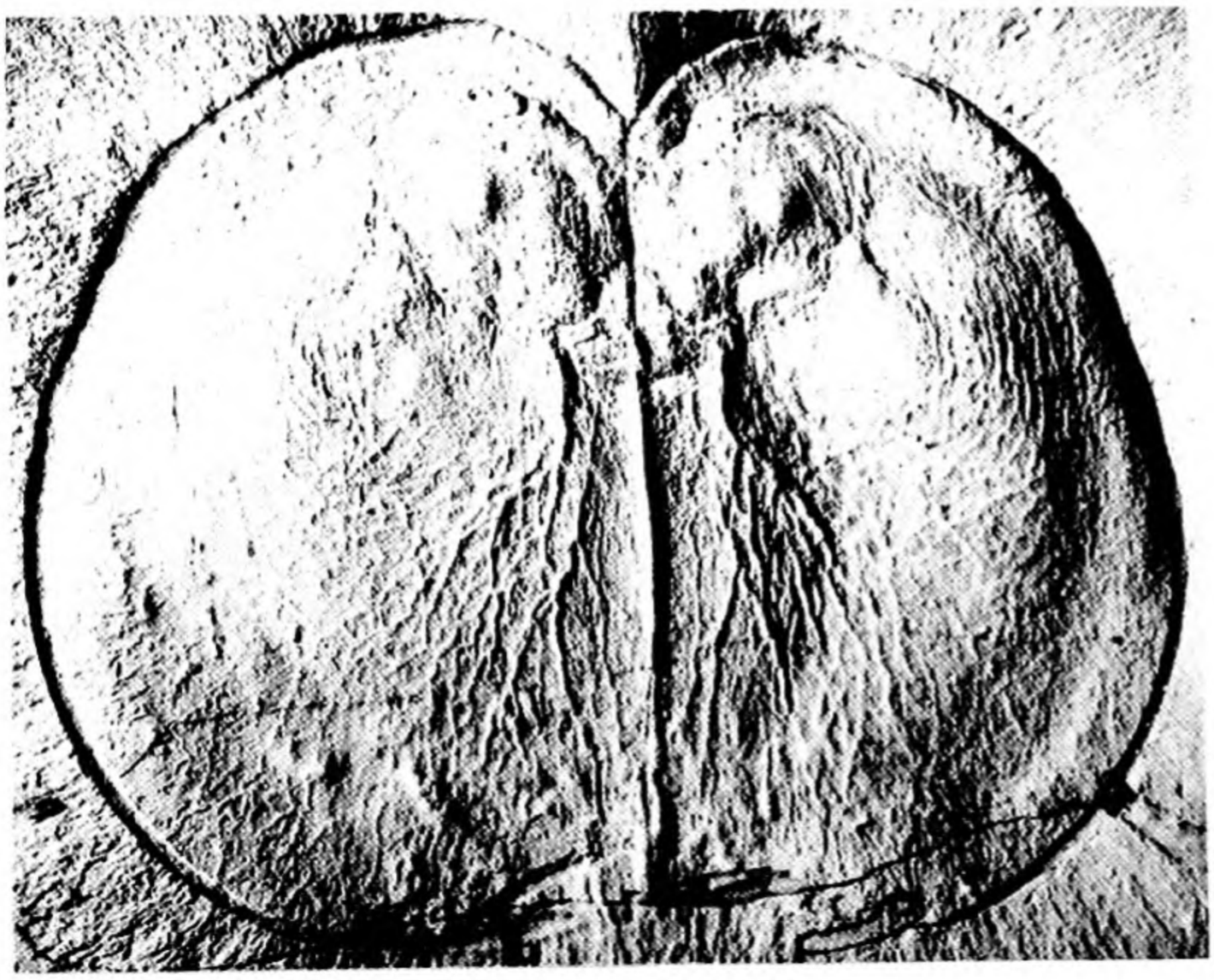

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P. haldemani Hall (**274**—6). **Dev.:** N. Y., Pa., Mich., Ia., Mo., Nev.; Mackenzie River, Canada.

P. rowi (Green) (**274**—10). **Dev.** (Hamilton): Ont.; N. Y., Mich., Ohio, Wis., Ill., Ia , Mo., Ark.

P. nevadae Hall and Clarke (**276**—8). **Dev.:** Nev.

P. missouriensis Shumard (**276**—9, 10). **L. Miss.:** Ohio (Waverly), Mo. (Louisiana).

REEDOPS R. Richter and E. Richter 1925

(**Phacops bronni* Barrande). Suberaniat furrow absent in front; eyes small, well forward; otherwise like *Phacops*. **L. Dev.**

R. deckeri Delo (**274**—14, 15). **L. Dev.:** Tenn. (Birdsong), Okla. (Haragan).

REMOPLEURIDES Portlock 1843

(**R. colbii*). Glabella faintly furrowed and with tonguelike, brimless anterior projection; eyes very long, extending around the posterior, nearly circular part of the glabella; thorax of 11 to 13 segments; pygidium small, wider than long, with two pairs of short spines. **Ord.** (N. America; Europe).

R. canadensis Billings (**267**—17–19). Genal spines short; pygidium with four flat spines posteriorly and two nodes anteriorly. **Chazyan:** Ont., Que.; N. Y., Va.

SCUTELLUM Pusch 1833

(= GOLDIUS Koninck 1841; BRONTEUS Goldfuss 1843; THYSANOPELTIS Hawle and Corda 1847)

(**S. costatum*). Cephalon semicircular, shorter than pygidium; glabella low, greatly expanded at front; glabellar furrows variable, from very long to almost obsolete; eyes close to glabella and to nuchal furrow; pygidium with short axial lobe, from which ribs radiate fanwise. **Ord.–Dev.** (rare in N. America and Arctic America; common in Europe).

S. lunatum (Billings) (**269**—15). Pygidium marked by six ribs radiating from each side of axial lobe; posterior ones straight, anterior ones curved backward; axial rib may be slightly bifid; all ribs flatten out and disappear marginally. **M. Ord.** (Trenton): Ont.; N. J., Minn.; Man.

S. acamas (Hall) (**269**—17). **M. Sil.** (Niagaran): Wis. and Ill. (Racine).

S. barrandi Hall (**269**—16). **L. Dev.** (Helderbergian): Ellesmereland; N. B.; N. Y.

SEVILLIA Weller 1936

(**S. sevillensis*). Differs from all American Carboniferous genera, except *Ditomopyge*, in possession of a preoccipital lobe; and from *Ditomopyge* in having a narrow but distinct anterior brim, curved preoccipital furrow, inflation of glabella on each side, between the lateral glabellar furrows, and broad blunt cephalon. **L. Penn.** (central N. America).

***S. sevillensis** Weller (**276**—14–16). **L. Penn.:** Ohio, Ill.

SHUMARDIA Billings 1862

(**S. granulosa*). Test small, ovate; cephalon minute, semicircular, eyeless, without concave border; glabella small, with peculiar lappetlike extensions of frontal lobe; pygidium without concave border, and with axial rings and pleural ribs equal in number, usually five. **Ord.** (N. America; Argentina; Europe).

***S. granulosa** Billings (**267**—8, 9). Surface granulose; glabella small. **Beekmantown:** Que.; Vt.

SPHAEREXOCHUS Beyrich 1845

(**S. mirus*). Glabella very convex or globular, with three pairs of lateral glabellar furrows, the posterior ones cutting off subcircular basal lobes; cephalon without genal spines; thorax of 10 segments; pygidium smaller than cephalon, composed of three segments, free at their ends. **Ord., Sil.** (N. America; Europe).

S. parvus Billings (**272**—16). Neck segment narrow with furrow deeply impressed; fixed cheeks small, rounded at genal angles, with wide border completely surrounding them. **M. Ord.** (Chazyan): Ont.; Vt., N. Y.

S. romingeri Hall (**272**—17–22). Larger than preceding and always conspicuous because of bulbose glabella. **M. Sil.** (Niagaran): Widely distributed throughout N. America.

SYNPHORIA Clarke 1901

(**Dalmanites* (*Synphoria*) *stemmatus*). Dalmanitid trilobites with more or less complete fusion and elevation of first two pairs of glabellar lobes, and reduction of second and third lateral furrows to submesial pits; cephalic margin smooth, crenulate, or with simple median protrusion; pygidial annulations about 15. **L. Dev.** (eastern N. America).

***S. stemmatus** (Clarke) (**273**—1, 2). **Oriskany:** N. Y., Md. (Ridgeley).

TELEPHUS Barrande 1850

(**T. fractus*). The brimless cephalon consists mostly of the glabella, palpebral lobes and eyes; glabella inflated, granulose or pustulose, with pits or faint indications of furrows; eyes as long as glabella or

PLATE 277

[Figures are x1 unless otherwise indicated.]

1. Hymenocaris perfecta (x2) [SMC 57 (6)]. Side view of right valve; *adm*, adductor muscle scar; *br*, gills; *i*, intestines; *thl*, thoracic legs. **2–4. Protocaris** spp. [USNM, Pr 76 (9)]. **2. P. marshi.** Retouched photograph of holotype to bring out certain features that may be seen by rotating the specimen. **3, 4. P. pretiosa.** Abdominal portion of body and both valves, with right intact and left crushed; counterpart of preceding, with shell removed to expose most of body. **5. Carnarvonia venosa** [SMC 57 (6); photograph furnished by C. E. Resser]. Dorsal view of two valves flattened on a shale surface. **6, 7. Anomalocaris** spp. **6. A. canadensis** [CGS, Pal Fos 3]. Outline of specimen in which nine abdominal segments are preserved besides the caudal segment. **7. A. gigantea** [SMC 57 (6); photograph furnished by C. E. Resser] Portion of abdomen showing segments and appendages.

longer, making up greater part of free cheeks; genal spines lateral. **M.** and **U. Ord.** (eastern N. America; northern Europe; Bohemia).

T. bicornis Ulrich (**267**—24–26). Anterior end of furrowless glabella bears a pair of spines. **Chazyan:** W. Va. (Whitesburg).

TERATASPIS Hall 1863

(**Lichas (Terataspis) grandis*). Glabella elongate; lobes quadricomposite; anterior lobe bulbous and tuberculate, completely circumscribed, with a depressed preoccipital area; pygidium with four pairs of barbed spines. **M. Dev.** (eastern N. America).

***T. grandis** (Hall) (**270**—30). **Onondaga:** Ont.; N. Y.

TETRALICHAS Phleger 1936

(= PLATYMETOPUS Angelin 1854;
PARALICHAS Reed 1902;
AMPHILICHAS Raymond 1905; and
ACROLICHAS Foerste 1920, parts of all)

(**Lichas laevis* Eichwald). Glabella broadly inflated and with quadricomposite lobes; axial lobe of pygidium with two furrows, narrowing posteriorly; differs from *Amphilichas* in having the longitudinal furrows well incised and in having quadricomposite lobes. **M.** and **U. Ord.** (N. America; Greenland; Europe; India).

T. jukesi (Billings) (**270**—7, 8). **Chazyan:** Newf.

T. minganensis (Billings) (**270**—13, 14). **Chazyan:** Eastern Canada; Vt., N. Y., Va.

T. trentonensis (Conrad) (**270**—9, 10). **Trenton:** N. Y., N. J., Pa. (Martinsburg), Va., Mo.

T. clermontensis (Slocom) (**270**—6). **L. Maquoketa:** Ia.

THALEOPS Conrad 1843

(**T. ovata*). Similar to *Illaenus*, but with deep, divergent dorsal furrows on cephalon, laterally extended eyes, and long, divergent genal spines. **M. Ord.** (Chazyan to Trenton) (widespread throughout N. America); **Sil.**

***T. ovata** Conrad (**268**—11–15). Genal spines triangular in section. **Black River, Trenton:** Ont.; widespread throughout U. S. A.

TRETASPIS McCoy 1849

(not TRETASPIS Murchison 1839 (*nomen nudum*))

(**Asaphus seticornis* Hisinger). Glabella flask-shaped with three pairs of furrows, the second and third deep; simple eyes or ocelli, and a fringe with concentric rows of pits, radially arranged. **Ord.** (eastern N. America; northern Europe).

T. reticulata Ruedemann (**267**—39–41). **Ord.:** N. Y. (Rysedorph), Md., Va. (Athens).

TRIARTHRUS Green 1832

(**T. beckii*). Body oval, with large cephalon and small pygidium; cephalon semicircular, depressed, with or without genal spines; eyes small, at or in front of midlength; facial sutures cut genal angles; glabella depressed to strongly convex, with two or three pairs of narrow, slightly impressed furrows; axial lobe of thorax somewhat more than a third of the total width; pygidium small, semicircular, with about six axial rings. **Ord.** (widespread throughout N. America; Newf.; Argentina; Europe).

***T. beckii** Green (**252**—17, 18; **276**—22). Glabella expands slightly forward, is rounded at front; the two pairs of glabellar furrows which reach the dorsal borders are almost parallel to nuchal furrow. **Trenton–Lorraine:** Que. to Va.

T. eatoni (Hall) (**276**—23). Differs from preceding in its parallel sided glabella with a squarish front, and in the more oblique glabellar furrows. **Trenton–Lorraine:** Ont.; N. Y., Pa.

TRIMERUS Green 1832

(**T. delphinocephalus*). Test relatively smooth, with extremely wide axial lobe; glabella quadrate, tapering forward, without furrows; pygidium triangular, with well defined ribs and axial rings. **Sil., Dev.** (N. America; Europe).

***T. delphinocephalus** Green (**272**—33). Dorsal shield convex; cephalon depressed in front; pygidium triangular, acute, with 12 annulations; entire surface granulose. **M. Sil.** (U. Clinton): Ont.; N. Y., Pa., Md., Ind., Ky.

T. vanuxemi (Hall) (**272**—32). Like preceding in form, but differs in the pygidial axis having 9 or 10 segments instead of 12, and in the anterior extremity of the cephalon being more broadly produced, giving it a shovel-like appearance; eyes situated upon elevated protuberances. **L. Dev.** (Helderbergian): N. Y., N. J., Md., W. Va.

TROCHURUS Beyrich 1845

(**T. speciosus*). Glabella convex; axial, longitudinal and fourth lateral furrows complete; lateral lobes strongly convex, set off from median lobe by deep furrows; third lateral furrows continuous across median lobe; pygidium with three pairs of discrete ribs, axial lobe with two furrows, narrowing posteriorly. **Sil.** (N. America; Europe).

T. phlyctainoides (Green) (**270**—1–4). **Niagaran:** N. Y., Ohio, Ind., Ill., Ark.

VOGDESIA Raymond 1910

(**Isotelus? bearsi*). Similar to *Brachyaspis* and *Homotelus*, but with much elevated eyes. **M.** and **U. Ord.** (N. America).

***V. bearsi** (Raymond) (**268**—4, 5). Eyes on tall stalks. **Chazyan:** Lake Champlain region.

V. vigilans (Meek and Worthen) (**268**—20, 21). Eyes moderately elevated; test strongly punctate. **Richmond** (Maquoketa): Ill., Ia.

XENOSTEGIUM Walcott 1924

(**Megalaspis belemnurus* White). Glabella long, expanding toward front, without glabellar furrows and with only traces of nuchal one; facial sutures turn

outward in front of eyes and reach margin without uniting in front as in *Megalaspis*; brim narrow, concave; pygidium triangular, without ribs, and with rings on only anterior part of axial lobe. **L. Ord.** (Cordilleran region of N. and S. America).

***X. belemnurum** (White) (**267**—30, 31). Pygidium short; posterior portion of axial lobe poorly defined. **L. Ord.:** Nev.

Subclass Homopoda [1]

Crustacea with two pairs of tactile organs, the other appendages trilobitan; biramous appendages on some or all the trunk segments; carapace present or absent; no facial sutures.

Order Pseudonotostraca. Carapace depressed; some of posterior segments without appendages.

PROTOCARIS Walcott 1884, emend Resser 1929

(**P. marshi*). Carapace bivalve; body many-jointed, 31 segments extending out from beneath carapace, the last broader than preceding and terminating in two spines. **L.** and **M. Camb.** (Vt., Pa.; B. C.).

***P. marshi** Walcott (**277**—2). **L. Camb.:** Vt. (Georgia), Pa. (Kinzers).

P. pretiosa Walcott (**277**—3, 4). **M. Camb.:** B. C. (Burgess).

Order Hymenocarina. Carapace compressed; rostrum free or attached; biramous appendages on anterior portion of trunk.

HYMENOCARIS Salter 1853

(**H. vermicauda*). Carapace large, bivalve, with large muscle scar near narrower rounded end; test thin. **Camb.** (N. America; Europe).

H. perfecta Walcott (**277**—1). **M. Camb.:** B. C. (Burgess).

CARNARVONIA Walcott 1912

(**C. venosa*). Carapace large, bivalve; adductor muscle scar near smaller, anterior end; prominent fine venation extends posteriorly from muscle scar region nearly to back margin. **M. Camb.**

***C. venosa** Walcott (**277**—5). **Burgess:** B. C.

ANOMALOCARIS Whiteaves 1892

(**A. canadensis*). Bodies with segmented abdomen, each segment with a pair of lamellate appendages which are gently rounded; posterior terminal segment with three pairs of spines; no carapace known; may represent the abdominal portion of *Tuzoia*, with which it usually occurs. **Camb.**

***A. canadensis** Whiteaves (**277**—6). Body with 9 to 13 segments, exclusive of caudal segment. **M. Camb.:** B. C. (Stephen).

A. gigantea Walcott (**277**—7). **M. Camb.:** B. C. (Burgess).

TUZOIA Walcott 1912

(**T. retifera*). Carapace consisting of two convex valvelike parts; shell thin, lateral portions semioval, narrowed anteriorly, probably curved evenly downward from dorsal line; each valve increasing in convexity from edges toward keel, which extends almost full length of shell; posterior margin usually with several large spines, remainder of margin commonly spinose except in extreme anterior portion; surface usually reticulate; meshes on keel and near dorsal line usually smaller and more crowded than on remainder of shell. **L.** and **M. Camb.** (Pa.; B. C.; Manchuria).

***T. retifera** Walcott (**278**—15, 16). **M. Camb.:** B. C. (Burgess).

Subclass Xenopoda

Crustacea with more or less eurypteridlike form; one pair of uniramous antennae; biramous appendages on anterior part of trunk; modified endopodites on cephalon.

SIDNEYIA Walcott 1911

(**S. inexpectans*). Body elongate, broadly oval in outline, and covered with a thin, smooth-surfaced dorsal shield, divided into a short cephalon, broad anterior abdomen, and narrow posterior abdominal portion; cephalothorax short and broad, eyes reniform and situated near posterolateral outer margin, ventral side with five pairs of movable appendages; abdomen with 12 segments, the first nine forming a broad elliptical portion and the last three narrow and elongate, the last one a broad caudal fin. **M. Camb.**

***S. inexpectans** Walcott (**279**—36). **Stephen:** B. C.

Subclass Archaeostraca

Crustacea with a compressed or more rarely a depressed carapace; appendages unknown.

Order Bradorina. Small ostracodelike crustaceans with muscle scar high on the anterior end. **Camb.**

BRADORIA Matthew 1899

(= BRADORONA Matthew 1902)

(**B. scrutator*). Carapace equivalved with a straight hinge line; surface closely punctate, otherwise even except for ocular tubercle located near anterodorsal corner; shell calcareo-corneous to phosphatic. **L.** and **M. Camb.**

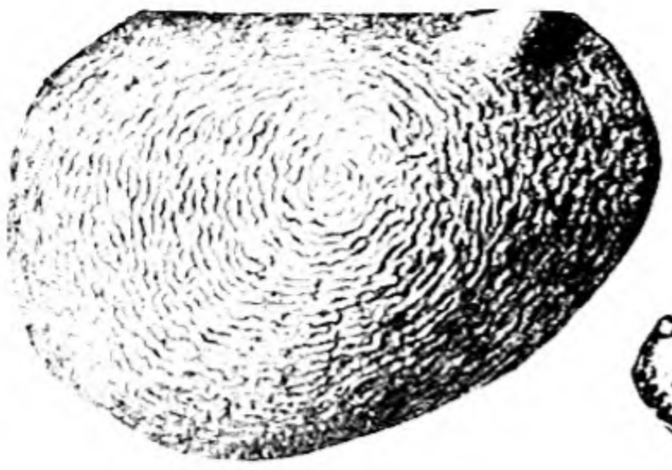
***B. scrutator** Matthew (**278**—2–4). Posterior end uniformly rounded; postcardinal and postventral angles comparatively obsolescent; ocular tubercle anterior; surface punctation relatively coarse. **L. Camb.:** N. S. (U. Etcheminian).

B. robusta (Matthew) (**278**—1). **L. Camb.:** N. S. (U. Etcheminian).

WALCOTTELLA Ulrich and Bassler 1931

(**W. apicalis*). Carapace bivalve, subovate, 3 to 7 mm long, hinge straight, rather long; valves moder-

[1] Dr. C. E. Resser kindly furnished several photographs of species originally figured by himself, by Ulrich and Bassler, or by Walcott. These are further acknowledged in the appropriate places.



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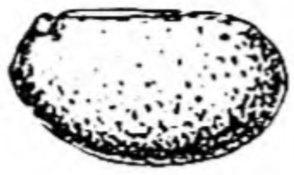

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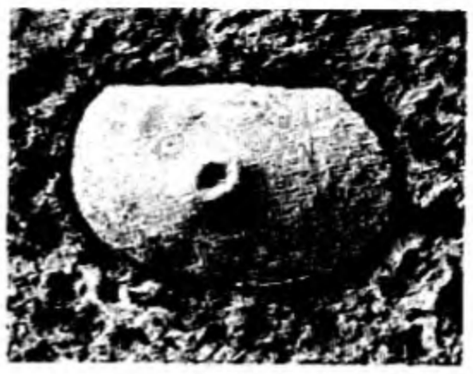

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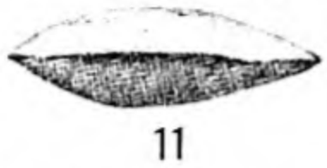

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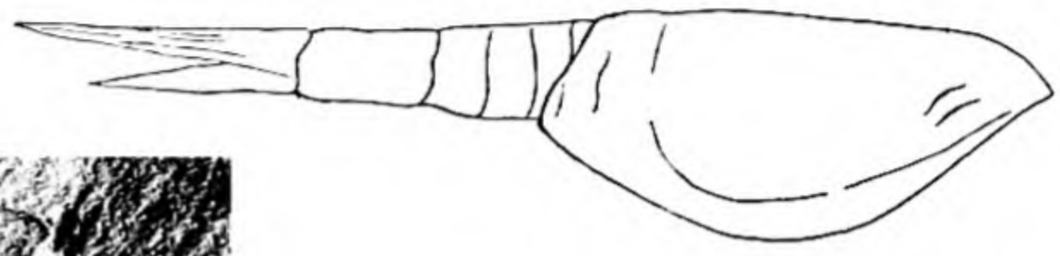

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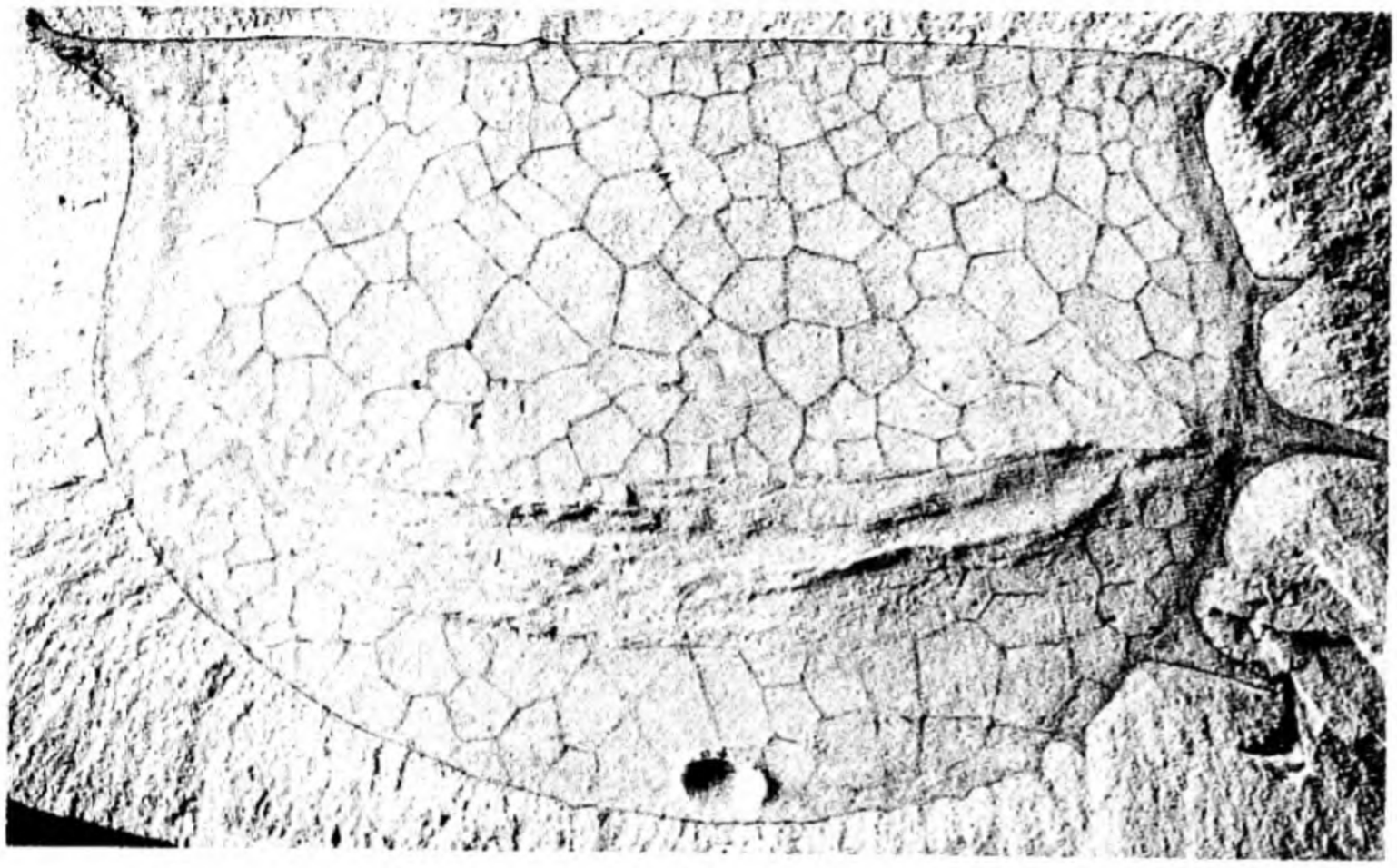

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ately convex, usually with a conical eminence situated in the median third of the length, and occasionally one or two much less conspicuous nodes near the anterodorsal angle; valve edges thin, bordered, gaping anteriorly and posteriorly; test phosphatic, thin, pliable, closely punctate exteriorly. **M. Camb.**

***W. apicalis** U and B (**278**—5). **M. Camb.:** Ariz. (Bright Angel).

BEYRICHONA Matthew 1886
(= ESCASONA Matthew 1902)

(**B. papilio*). Characterized by subtriangular outline of valves, and a broad, undefined depression in the dorsal slope. **L.** and **M. Camb.**

***B. papilio** Matthew (**278**—7). **L. Camb.:** N. B. (Hanfordian).

B. tinea Matthew (**278**—6). **L. Camb.:** N. B. (Hanfordian).

HIPPONICHARION Matthew 1886

(**H. eos*). Like *Beyrichona* in shape of valves, mid-dorsal depression, and in disposition of surface ridges and nodes; characterized by greater distinctness of lateral ridges, these extending as sharply defined elevations from cardinal angles to a point near middle of ventral border. **L.** and **M. Camb.**

H. minus (Matthew) (**278**—14). **L. Camb.:** N. B. (Hanfordian).

INDIANA Matthew 1902 emend Ulrich and Bassler 1931

(**I. lippa* Matthew, selected by U and B). Distinguished from *Bradoria* by the entire absence of ocular and other tubercles, greater gape in ends and ventral parts of carapace, and in slight inequality of dorsal parts of valves; shell surface polished. **L.** and **M. Camb.**

I. faba Ulrich and Bassler (**278**—8–12). **M. Camb.:** Ariz. (Bright Angel).

DIELYMELLA Ulrich and Bassler 1931

(**D. recticardinalis*). Differs from *Indiana* by greater development and more prowlike shape of anterior part, and wider gape of valves. **L.** and **M. Camb.**

***D. recticardinalis** U and B (**278**—13). **L. Camb.:** Ariz. (Bright Angel).

Order Ceratiocarina. Carapace bivalve with rostrum free.

CERATIOCARIS McCoy 1849

(**C. solenoides*). Carapace consisting of a smooth, pod-shaped, bivalve shell, without eye nodes; valves of carapace elongate, subovate, or subquadrate, narrow in front, truncated (but not incurved) behind; a free lanceolate rostrum occurs; body of 14 or more segments, of which from 4 to 7 extend beyond carapace; some of these have obscure branchial appendages; telson a long-pointed spine, with two smaller lateral spines (cercopods) articulated to it. **Ord., Sil.**

C. acuminata Hall (**278**—17, 18). Carapace large, tapering in front, broad medially, and rather abruptly truncated behind; surface with fine, raised, longitudinal lines; the next to the last segment long; telson and lateral spines short. **M. Sil.:** N. Y. (Bertie).

CARYOCARIS Salter 1862

(**C. wrightii*). Carapace long, pod-shaped, bivalve, rounded anteriorly, subtruncate behind, and with back and front subparallel; hinge pits distinct; surface smooth or with oblique wrinkles near margins; commonly occurs with graptolitic assemblages. **Ord.** (N. America; S. America; Europe; Australia), **Sil.**

C. curvilata Gurley (**279**—3, 4). **Ord.:** Widespread throughout N. America in graptolitic shales.

C. oklahomensis Decker (**279**—1, 2). **Sil.:** Okla. (Henryhouse).

COLPOCARIS Meek 1872

(**C. bradleyi*). Carapace smooth, with deep anterior marginal sinus and sharp extremity; caudal plate with three spines. **Dev., Miss.**

C. woodfordi Cooper (**279**—17–19). **Dev.:** Okla. (Woodford).

C. elytroides (Meek) (**279**—20–24). **Dev.:** Okla. (Woodford); **Miss.:** Ky. (Waverly).

C. bradleyi Meek (**279**—16) **Miss.:** Ky. (Waverly).

ECHINOCARIS Whitfield 1880

(**E. sublevis*). Short-hinged, bivalve, suboval shell which is broad in front, with free rostrum, not curved behind, and without posterolateral spines; a single S-shaped keel on each valve and sometimes a small accessory ridge near hinge; surface punctate and pustulose; six of body segments exposed and bearing small spines on their surface and posterior margin; telson and lateral spines of unequal size. **Dev.**

PLATE 278

[Figures are x1 and from USNM, Pr 78 (4), unless otherwise indicated.]

1–4. Bradoria spp. 1. B. robusta. Right valve (x8), showing surface sculpture. **2, 3. B. scrutator** [CGS, Camb Cape Breton]. A fully exposed shell (x4); the type, a left valve, x6, with ventral portion hidden by matrix. **4. B. scrutator.** A small left valve (x4). **5. Walcottella apicalis.** Left valve (x4). **6, 7. Beyrichona spp.** (x4). **6. B. tinea.** A specimen with two valves extended. **7. B. papilio.** Right valve. **8–12. Indiana faba** (x4). Dorsal and right side views of a shell; anterior view of another specimen showing gap; dorsal and left side views of a third shell. **13. Dielymella recticardinalis.** A large and typical right valve (x3). **14. Hipponicharion minus.** A right valve (x6). **15, 16. Tuzoia retifera** [USNM, Pr 76 (9)]. Left valve retaining three large rear spines; a new photograph of the original holotype figured by Walcott. **17, 18. Ceratiocaris acuminata.** 17: Outline (x0.3) showing one of the lateral spines [NAIF]. 18: Posterior portion [N Y St Mus, B 265].

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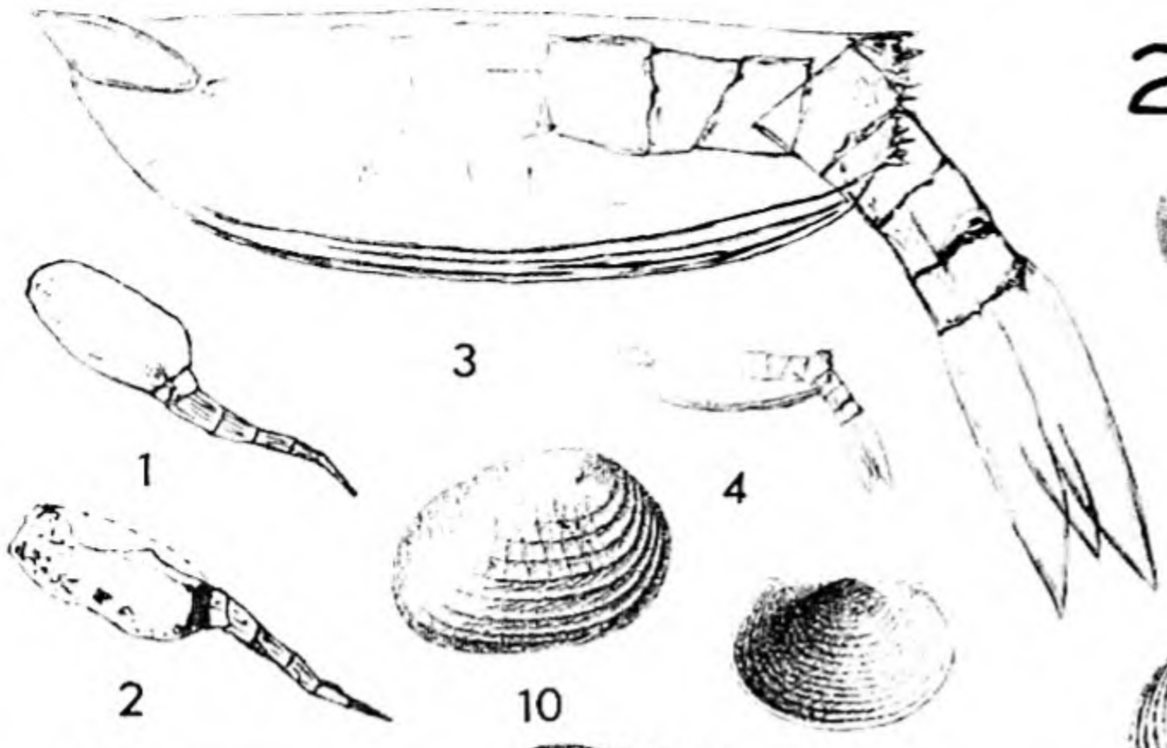
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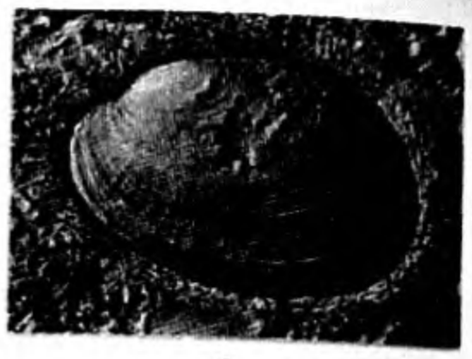
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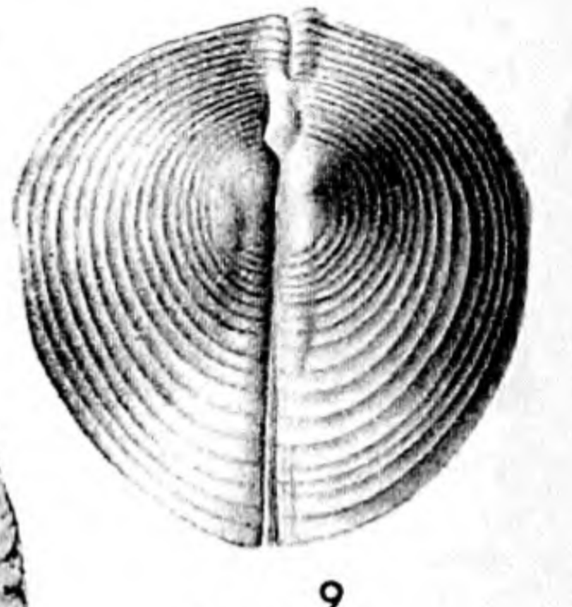
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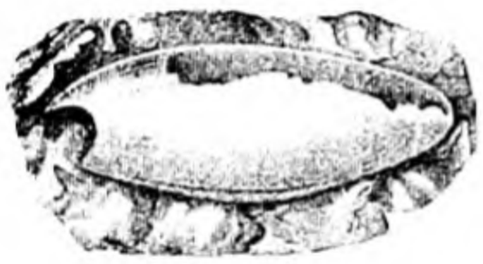
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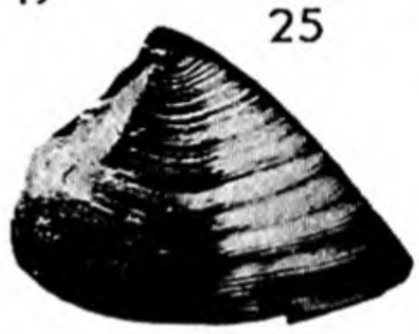
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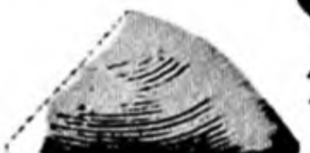
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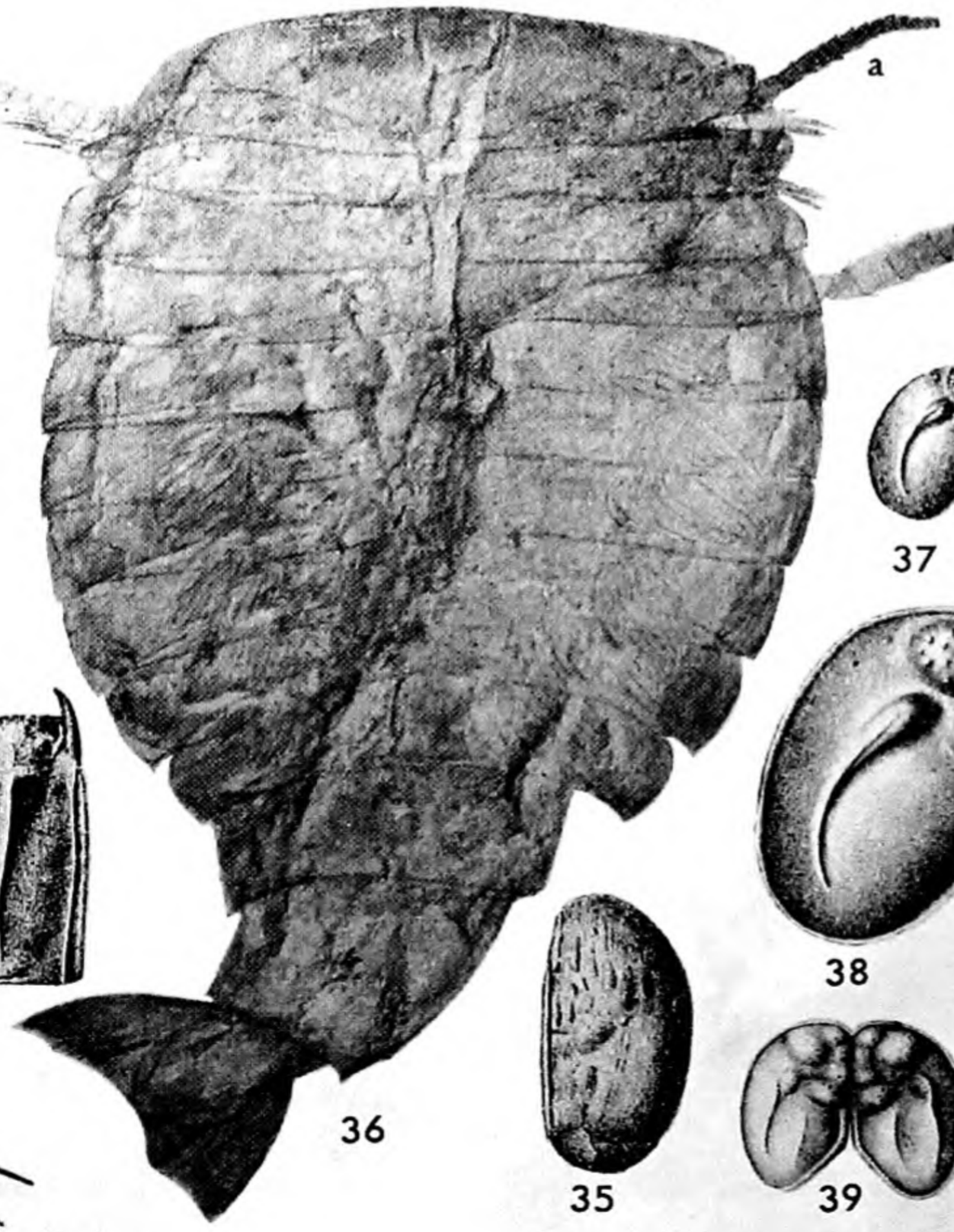
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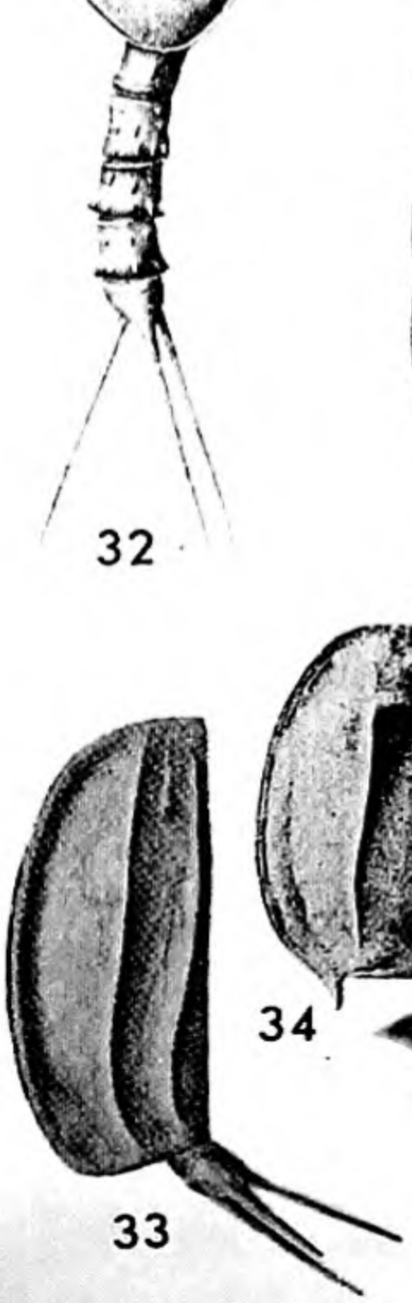
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E. punctata (Hall) (**279**—42). **Hamilton–Ithaca:** N. Y., Wis.

E. socialis Beecher (**279**—32, 39). **Chemung:** N. Y., Pa.

***E. sublevis** Whitfield (**279**—37, 38, 41). **U. Dev.:** Ohio

TROPIDOCARIS Beecher 1884

(**T. bicarinata*). Carapace bivalve, with truncate posterior margins divided by median lanceolate plate and an elongate rostral plate in cephalic region; eye node well defined; other nodes of cephalon obscure; rostrum narrow and ridged; valve surfaces with one or more strong, longitudinal keels; abdomen with two exposed segments which are subcylindrical and without small spines. **U. Dev., Miss.**

***T. bicarinata** Beecher (**279**—33). Two strong, lateral carinae, and a shorter intercalated one in cephalic region. **Chemung:** Pa.

T. alternata Beecher (**279**—40). Valves elongate with seven alternating longitudinal carinae and two spines on posterior margin which are continuations of fifth and sixth carinae; stronger carinae with pits on summit; several minor intercalated carinae in cephalic region. **Miss.:** Pa. (Waverly).

Order Rhinocarina. Carapace bivalve, with free rostrum and narrow median dorsal plate separated from valves by straight or slightly curving hinge at each side; ocular nodes clearly defined, with distinct pit at summit.

RHINOCARIS Clarke 1888

(**R. columbina*). Valves in contact at only a single point; divided by median dorsal plate and anterior rostrum; carapace smooth, except for fine, raised longitudinal striae; ocular nodes well defined; posterior margin concave; abdomen with two or three segments, the last one the longest, all diagonally striated; telson broad; lateral spines fimbriated on their margins. **Dev.**

***R. columbina** Clarke. Rostrum long and slender; median plate spatulate; broadening furrows diverge backward from eyes; lateral carinae faint. **Hamilton:** N. Y.

R. scaphoptera Clarke (**279**—34). Rostrum strongly curved, rather thick; valves with posterior ventral spinous prolongation and strong lateral carina; surface with elevated lines parallel to ventral margin, strong and frequently interrupted. **Hamilton, Ithaca:** N. Y.

R. capsella Hall and Clarke (**279**—35). **Hamilton, Ithaca:** N. Y.

Order Discinocarina. Subcircular or oval, chitinous shields, with a triangular rostrum filling an anterior notch; surface ornamented with raised concentric lines.

SPATHIOCARIS Clarke 1882

(**S. emersoni*). Carapace in one piece, oblong elliptical, convex, with apical point near focus of the ellipse, from which point a cleft extends posteriorly, widening to margin. **Dev.**

S. woodfordi Cooper (**279**—25–29). **Woodford:** Okla.

Archaeostraca Incertae Sedis

EOPTERIA Billings 1865

(**E. typica*). Carapace bivalve, closely resembling the pelecypod genus *Pterinea* in general form; valves equally convex. **L. Ord.** (Newf.; eastern N. America).

***E. typica** Billings. **Canadian:** Newf.

E. richardsoni Billings (**297**—7, 8). **Beekmantown:** Que.

RIBEIRIA Sharpe 1853

(**R. pholadiformis*). Arched, univalve shell without corrugations, with strong beaks, and open at the ends and along basal margin; a thick, transverse internal plate marks anterior extremity, behind which is a corrugated boss for muscle attachment. **Ord.** (eastern N. America).

R. (**Ribeirina**) **calcifera** Billings (**297**—17–19). **Beekmantown:** Eastern Canada; Pa.

R. nuculitiformis Cleland (**297**—20–22). Differs from preceding in presence of fold near dorsum and in depth of notch. **Beekmantown:** N. Y. (Tribes Hill).

Subclass Branchiopoda

Primitive crustaceans with elongate form; some lack shells, whereas others have a chitinous or cal-

PLATE 279

[Figures are x1 unless otherwise indicated.]

1–4. Caryocaris spp. 1, 2. C. oklahomensis (x4) [JP 9]. Holotype and counterpart. **3, 4. C. curvilata** [GSA, M 2]. Complete specimen (x4, x1). **5, 6. Fordilla troyensis** (x6) [USNM, Pr 78 (4)]. Impression of valve interior; well preserved left valve. **7–9. Schizodiscus capsa** [Pal N Y 7]. A specimen of normal proportions; profile and top views of an enlarged specimen (x3). **10–15. Estheria** spp. [N Y St Mus, Rp Pal 1900]. **10–12. E. ortoni** (x8). Small right valve and two larger left valves. **13–15. E. membranacea.** Interior view (x4); exterior view of a young shell (x8), and of a mature shell (x4). **16–24. Colpocaris** spp. **16. C. bradleyi** [Pal Ohio 2]. **17–19. C. woodfordi** [JP 6]. Right side and anterior views (x0.5); diagram of digestive muscle attachment (x7). **20–24. C. elytroides.** 20: A right carapace in matrix [Pal Ohio 2]. 21–24: Right side and anterior views; diagram of digestive muscle attachment (x6); dorsal view. **25–29. Spathiocaris woodfordi** (x0.7) [JP 6]. 25, 27: Median and left side views of an incomplete specimen. 26: Complete valve. 28, 29: Median and left side views of a nearly complete specimen. **30, 31. Leaia tricarinata** (x2) [Ind G S 13]. Top and side views of complete shell. **32. Echinocaris socialis** [Pal N Y 7]. A nearly complete mature individual (x2). **33. Tropidocaris bicarinata** (x1.3) [GSL, QJ 58]. Folded carapace with abdomen, telson, and cercopods exposed. **34, 35. Rhinocaris** spp. [N Y St Mus, Rp Pal 1900]. **34. R. scaphoptera.** Left exterior. **35. R. capsella.** Right view of folded carapace. **36. Sidneyia inexpectans** [SMC 57 (2)]. A large dorsal shield; *a*, antenna. **37–39. Echinocaris** spp. [Pal N Y 7]. **37, 38. E. sublaevis.** The type specimen (x1, x2). **39. E. socialis.** An expanded carapace, somewhat enlarged. **40. Tropidocaris alternata** (x1.3) [GSL, QJ 58]. Entire left valve. **41, 42. Echinocaris** spp. [Pal N Y 7]. **41. E. sublaevis.** Portion of abdomen and postabdomen (x2). **42. E. punctata.** A nearly entire specimen.

carco-chitinous carapace or a calcareous bivalve shell; habitat, all kinds of water. **L. Camb.–Recent.**

Order **Conchostraca.** Carapace bivalve, chitinous, or calcareo-chitinous; eyes sessile; 10 to 27 pairs of appendages; shells frequently confused with ostracodes and small molluscan shells, from which they are often difficult to differentiate. **L. Camb.–Recent.**

FORDILLA Walcott 1886

(**F. troyensis* Barrande). Outline like a pelecypod, but shell calcareo-phosphatic and very small; possesses typical conchostracan characters. **L. Camb.**

***F. troyensis** Barrande (**279**—5, 6). **L. Camb.:** N. Y.

SCHIZODISCUS Clarke 1888

(**S. capsa*). Carapace bivalve, shield-shaped, with a straight hinge which is in the major axis of the shield; each valve nearly a semicircle; surface concentrically ridged. **Dev.** (N. Y., Pa.).

***S. capsa** Clarke (**279**—7–9). Beak somewhat eccentric; anterior end curved to less radius than posterior; concentric striation regular. **Hamilton:** N. Y.

LEAIA Jones 1862

(**Cypricardia leidyi* Lea). Carapace angulated by diagonal ridges which extend from near beak to lower margin. **Penn., Perm.** (N. America; Europe).

L. tricarinata (Meek and Worthen) (**279**—30, 31). Three smooth carinate ridges, the anterior curved, the dorsal ones defining an escutcheonlike area. **Penn.:** Ind., Ill.

***L. leidyi** (Lea). Ridges beaded, anterior one straight; no dorsal one; concentric ridges fewer and more distant than in preceding. **Pottsville:** Pa.

ESTHERIA Rüppell 1837

(**E. dahalacensis*). Carapace bivalve; valves thin, hence, unlike ostracodes, wrinkled when crushed; valves rounded and united by a straight, toothless margin; external surface with concentric ridges, between which are more or less regularly interlacing or branching striae; beaks not sharply defined, the umbonal region in some species bearing an eyespot or anterior muscle scar; habitat, fresh and brackish waters. **Dev.–Recent.**

E. membranacea Pacht (**279**—13–15). **Dev.:** N. Y. (Oneonta–Catskill). Old Red Sandstone of Scotland and Russia.

E. ortoni Clarke (**279**—10–12). **L. Penn.:** Ohio (Conemaugh). (Occurs with *Leaia tricarinata.*)

E. ovata (Lea). Similar to preceding, but about twice as large, and beak is nearer the regularly rounded anterior end; valves equal and without radiating ridges; surface finely pitted and with strong concentric lines. **Trias.:** Newark of Pa., Va., N. C., S. C., Utah.

Subclass Ostracoda[1, 2]

General Features. Ostracoda are small, aquatic or more commonly marine crustaceans, indistinctly segmented and completely inclosed by a horny or calcareous bivalve *carapace.* The valves are right or left in position, hinged dorsally where they are joined by a membrane, and in contact or overlapping ventrally.

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[1] In revising and illustrating the Ostracoda we have had the advice, suggestions, and assistance of the following specialists: C. I. Alexander, R. S. Bassler, C. H. Blake, C. L. Cooper, C. G. Croneis, H. V. Howe, the late E. M. Kindle, Betty Kellett Nadeau, and F. M. Swartz. To these we extend our grateful acknowledgments.

Generic characterizations are based largely on the descriptions by Ulrich and Bassler and by Bassler and Kellett (see list of references); the taxonomic order of genera is essentially that suggested to us by Swartz, who also contributed to the introductory remarks and to the discussion of orientation. It is assumed that the investigator will have access to the works of Bassler and Kellett, and of Swartz; hence family characterizations have been omitted but the genera are discussed and illustrated in family groups.

[2] Few references to Paleozoic Ostracoda previous to Jan. 1, 1934, are listed here because the bibliography in Bassler and Kellett (see below) is assumed to be complete to that date; many other references not listed here, especially those on Mesozoic and Cenozoic genera, will be found in some of the works cited below.

Students of Cretaceous and Tertiary Ostracoda are dependent upon European authors for descriptions and classifications of most genera. The two most important European references (both dealing with Recent species) follow: **Sars, G. O.,** An account of the Crustacea of Norway, v 9, Ostracoda, p 1–277, pl 1–119, 1928, published by the Bergen Museum and sold by Alb. Aammermeyers Forlag, Oslo. **Müller, G. W.,** Fauna and Flora des Golfes von Neapel . . . [and the adjoining sea area], published by the Zoological Station of Naples, Mon 21: 1–404, pl 1–40 (double and colored), 1894. This report is most important, not only for ecological discussions, but because Müller's descriptions of the finer parts of the carapace have made possible the proper recognition of Cretaceous and Tertiary genera and species.

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Since the valves are held on the right and left sides of the bilaterally symmetrical animal, they tend to be mirror images of each other. This fundamental symmetry is commonly disturbed, however, though in general inconspicuously, by overlap of one valve on the other along the free margins, the hinge, or both; by difference in convexity, especially in the dorsal region, or by differential protrusion of parts of the margin; or, very rarely, by dissimilarities of surface ornamentation. In addition, some ostracodes exhibit dimorphic swellings of the valves, which if strongly developed give two groups of individuals of markedly different aspect. Appreciable structural changes from immature to adult stages have also been demonstrated for some groups of ostracodes.

Criteria Used in Identifying and Classifying Ostracoda. The classification of modern Ostracoda is

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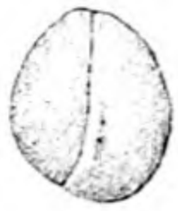
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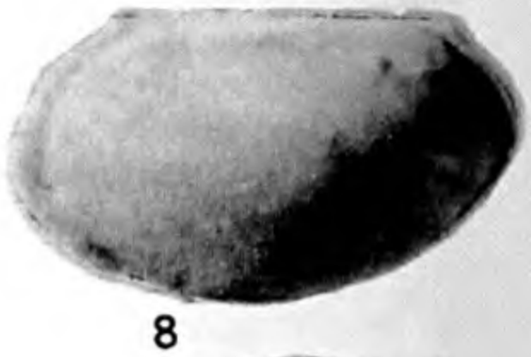
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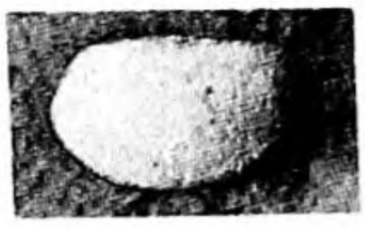
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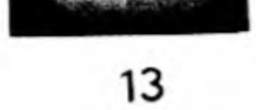
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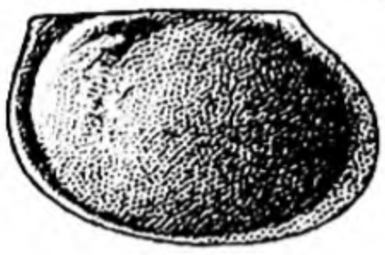
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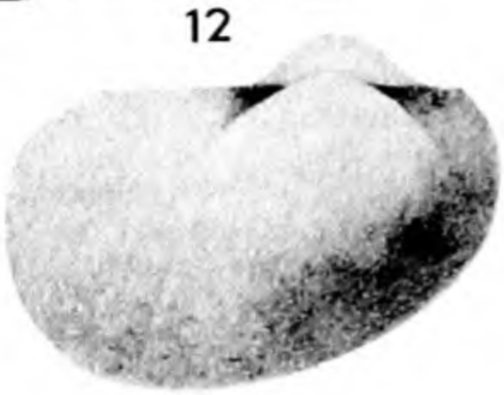
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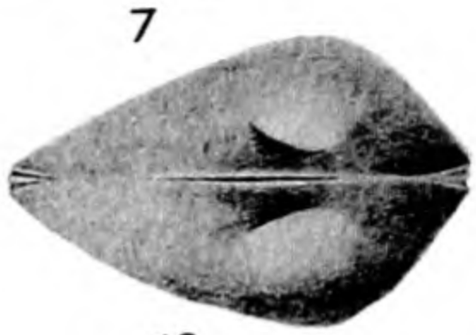
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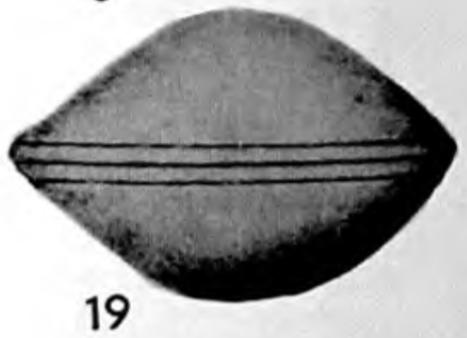
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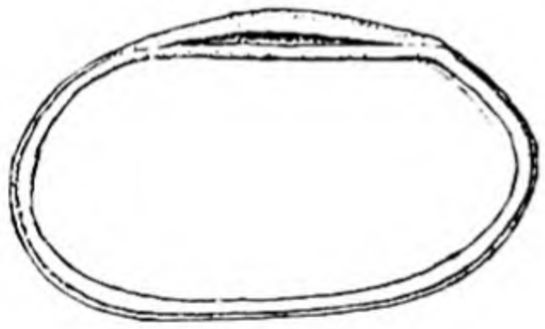
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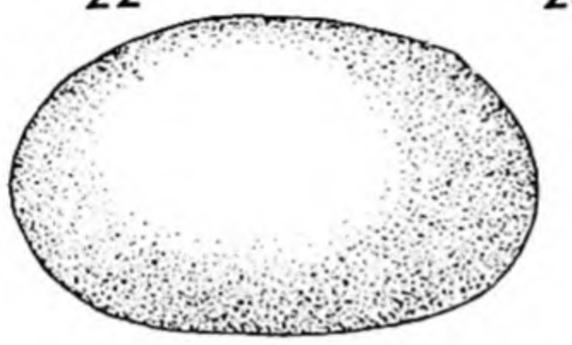
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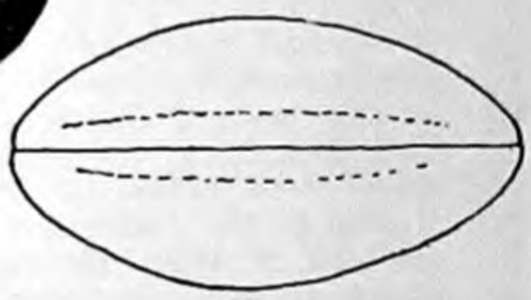
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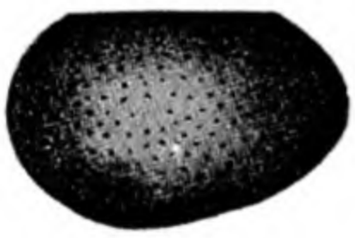
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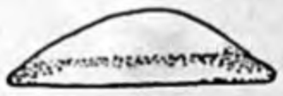
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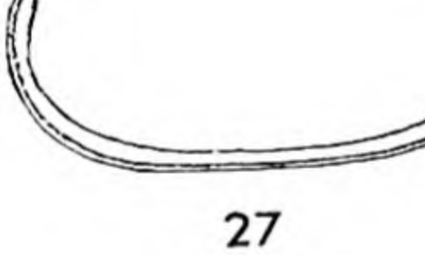
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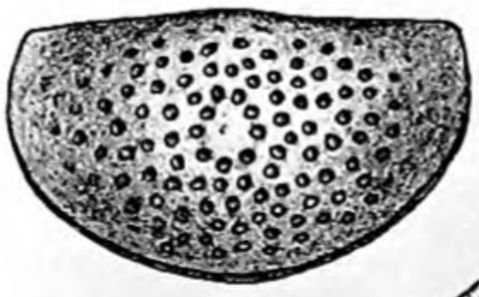
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based to an important extent on features of the appendages. Since these are not observable in fossil material, relationships must be determined from the valves of the carapace alone. The following carapace features are useful in identifying and classifying fossil ostracodes: (1) Shape or outline as seen in side view; (2) general characteristics of surface ornamentation; (3) nature and position of adductor muscle scars; (4) contact relations of valves; (5) nature of dimorphic structures if developed; (6) microstructure of shell material.

The significance of these features, both separately and in combination, varies widely in different groups and must be determined by careful studies of persistence through related species and genera.

Contact Relations of Valves. The valves of an ostracode carapace may meet in simple contact, or one may overlap the other along the free margins. In the latter case the larger valve may have a groove or rabbet for receiving the edge of the smaller. The hingement may be simple or specialized; if specialized, there may be interlocking bars and grooves together with denticulations and sockets.

Microstructure of Shell Material. The valves of modern ostracodes consist of two shell layers. The outer lamella is the thicker and is calcified throughout; the inner lamella may be membranous, as in the Cytherellidae, but usually consists of a calcified peripheral area and a central membranous area. The calcified part of the inner lamella is fused to the outer, in some genera entirely, in others only in a peripheral zone. The inner line along which the two unite is the line of concrescence (pl **291, 292**).

The actual inner edge of calcification of the inner lamella is designated the *inner margin*, and it may lie either at or well within the line of concrescence, depending upon the width of the calcified portion of the inner lamella and upon the width of the zone of concrescence. The line of concrescence and inner margin may closely parallel the outer margin of the valve, or they may deviate from it in varying degree, and either one or both may exhibit a highly complex and sinuous course. The position of the line of concrescence, in terms of the outer margin of the valve, and its relation to the inner margin as well, are of much taxonomic significance.

The walls of the valves are pierced by numerous canals which open on both the inner and outer surfaces. Two types of canals are recognized. *Radial canals* pierce the outer margins of the valves and open internally along the line of concrescence; *pore-canals* lie perpendicular to the valve surface. In different species and genera the canals may vary in number, size, and nature. Radial canals, for instance, may develop bulbous enlargements and funnel-shaped openings.

The characteristics of the inner lamella and of the pore canals in modern, Tertiary, and Cretaceous ostracodes have been used extensively by numerous investigators in the last few decades, and are certain to continue in importance in future studies. In ostracode assemblages of Paleozoic age, however, preservation of shell matter is rarely good enough for the determination of microstructure.

Orientation. Orientation of Recent ostracodes, based on full knowledge of the animal's anatomy, can be applied with confidence to the many closely related Tertiary and Cretaceous forms. Paleozoic ostracodes, however, are far removed from modern types, and there is wide divergence of opinion among specialists both as to actual and comparative orientations and valid criteria which may be used in determining orientation.

Numerous investigators[1] have considered the moot question and have then tried to follow some definite practice more or less consistent with the principles they erected. These attempts have resulted in considerable disagreement and confusion, and it is beyond the scope of the present discussion to attempt a complete analysis of the question of orientation. It seems advisable, therefore, to use the same descriptive and caption designations employed by the investigators from whom characterizations and illustrations have been taken. We shall, in some instances however, purposely avoid the question of orientation by the simple expedient of using *side* or *lateral* instead of *right* or *left*, and *end* instead of *anterior* or *posterior*.

[1] Ulrich and Bassler 1908, 280–282; 1923, 283–285. Bonnema 1930, 109–120; 1932, 288–295. Kummerow 1931, 155–159. Geis 1932, 150–155. Swartz 1933, 231–243; 1936, 557–562. Warthin 1933, 442. Croneis 1939, 27–32.

PLATE 280

1–12. Leperditia spp. 1–4. L. fabulites [Minn G S 3 (2)]. Left side, posterior, dorsal, and ventral views (x2). **5–8. L. scalaris** (x3) [original from F. M. Swartz]. Left side view of large specimen; dorsal, left, and right side views. **9–12. L. alta** (x3) [Md G S, Sil]. Two right and two left valves respectively, the last two preserving the eye-spot. **13–16. Isochilina spp. 13. I. ottawa** (x1) [Ala G S, S R 14]. **14–16. I. jonesi** [Md G S, Sil]. Ventral edge of left valve (x1); end view of carapace with valves separated (x1.3); left valve (x1.3). **17–21. Aparchites spp., 17–19. A. canadensis** [JP 14]. Right side, dorsal, and ventral views (x30). **20. A. whiteavesi** [Md G S, Sil]. Valve exterior (x10). **21. A. minutissimus** (x50) [Md G S, Camb and Ord]. **22–30. Paraparchites spp. 22, 23. P. nicklesi** [USGS, B 439]. Left and right valves (x10). **24, 25. P. wapanuckensis** [JP 2]. Dorsal and left side views (x25). **26. P. inornatus** [DUB, JSL 33]. Left valve (x30). **27–30. P. humerosus** (x20) [USNM, Pr 30]. Right interior showing linear socket for reception of edges of opposite valve; exterior of genotype; end and ventral views. **31–34. Leperditella spp. 31. L. rex** [JP 15]. Left exterior of lectotype (x16.5). **32–34. L. tumida** (x10) [Md G S, Camb and Ord]. Right valve; dorsal and posterior views in outline. **35–37. Schmidtella crassimarginata** [Minn G S 3 (2)]. Posterior, ventral, and right side views (x10). **38–40. Saccelatia arrecta** [JP 14]. Dorsal, lateral, and ventral views (x30). **41–44. Macronotella spp. 41. M. rugosa** [JP 14]. Side view of left valve (x30). **42–44. M. scofieldi** [Minn G S 3 (2)]. Side, ventral, and end views (x20). **45–48. Cyathus ulrichi** [JP 4]. Dorsal, right side, anterior, and ventral views (x40). **49, 50. Paraechmina spinosa** [Md G S, Sil]. Drawing and photograph of right valve (x20). **51–55. Aechmina spp. 51, 52. A. richmondensis** [Md G S, Sil]. Side and end views (x20). **53. A. cuspidata** [Md G S, Sil]. Left valve (x20). **54, 55. A. lonensis** [JP 14]. Left side and dorsal views of holotype (x30). **56–59. Primitia spp. 56, 57. P. seriata** [JP 10]. Right exterior and interior (x29). **58, 59. P. (?Plethobolbina) lativia** [CGS, Contr Can Micro-Pal 2]. Left valve and section (x18). **60, 61. Aechmina bigeneris** [JP 10]. Side and ventral views of squeeze from holotype (x30) — an impression of a left exterior.

History and Study. Most modern ostracodes live in marine or brackish water; the Cypridae, however, inhabit fresh water. They are gregarious and live either as plankton or as benthos at almost any oceanic depth. Most ostracode shells are small and many may be overlooked unless searched for with a lens. Washings of shales and residues from dissolved rocks often yield well preserved shells. Fossil ostracodes first appear in Ordovician rocks and are well represented throughout the subsequent periods to the Recent.

In the past 20 years Ostracoda have been extensively studied because of the recognition by petroleum geologists of their value for surface and subsurface correlation. This great impetus to their study has carried into the educational institutions and has resulted in the description and illustration of many new genera and species as well as in considerable taxonomic rearrangement. Only about half of the known fossil genera have been included, but the omitted ones are of relatively little importance at the present time.

LEPERDITIA Rouault 1851

(**L. brittanica*). Shell suboblong with an oblique backward swing; comparatively large, commonly exceeding 8 mm in length; dorsal edge straight, generally angular at the extremities; ventral outline rounded, greatest thickness in ventral half, lower edge usually also blunt; valves unequal, right larger and overlapping ventral edge of left; hinge simple; surface frequently horny in appearance, smooth and glossy in most cases, granulose or minutely punctate in others; a small tubercle or eye-spot generally present on anterodorsal fourth, while a large rounded, subcentrally situated muscular imprint is a well marked feature of the interior and sometimes distinguishable even on the exterior; several hundred species. **Ord.–Carb.**

L. fabulites (Conrad) (**280**—1–4). Eye tubercle small; hinge line central; one of the best index fossils of the **Mid-Ordovician.** Widespread in eastern N. America in Stones River and Black River strata.

L. alta Conrad (**280**—9–12). Small, nearly symmetrical, strongly convex; length 1.5 times height; eye tubercle pronounced, one-fourth of valve length from anterior end, and same distance from dorsal line. **Sil.:** Cayugan and Keyser of eastern N. America.

L. scalaris (Jones) (**280**—5–8). **Cayugan:** Ont. (Akron); N. Y. (Cobleskill).

ISOCHILINA Jones 1858

(**Leperditia ottawa*). Like *Leperditia*, but exteriorly valves appear equal in every respect though actually within left valve is a sloping area which is overlapped by a corresponding beveled edge of the right valve; surface may be lobed or nodose. **Ord.–Dev.**

***I. ottawa** (Jones) (**280**—13). **L. Ord.:** Que. (Beekmantown); Ala. (Ridley).

I. jonesi Wetherby (**280**—14–16). **M. Ord.:** Ky. (Perryville), Tenn., Ala. (Cannon).

APARCHITES Jones 1889

(**A. whiteavesi*). Shell not over 3 mm long, equivalved, subovate or oblong; hinge straight, ventral edge thickened, often beveled or channeled; surface convex, mostly in ventral half, smooth. **Ord.–Dev.**

***A. whiteavesi** Jones (**280**—20). **Richmond:** Man.

A. minutissimus (Hall) (**280**—21). **U. Ord.:** Anticosti; N. Y., Ohio; Man.

A. canadensis Fritz (**280**—17–19). **M. Dev.:** Ont. (Onondaga).

PARAPARCHITES Ulrich and Bassler 1906

(**P. humerosus*). Like *Leperditia*, except for smaller size; like *Aparchites*, but with ventral edge of right valve overlapping simple beveled edge of left, and dorsal edge of left overlapping right valve; smooth spine often present in anterodorsal angle. **Dev.–Perm.**

P. nicklesi Ulrich (**280**—22, 23). Hinge line prominent; anterior end more oblique than posterior; eye tubercle sharp; convexity moderate. **Miss.:** Ky. (Chester), Ill. (Warsaw, Clore), Mo. (Bushberg, Chouteau), Ark. (Moorefield, Batesville, Fayetteville), Wyo. (Amsden).

P. inornatus (McCoy) (**280**—26). **Chester:** Ill. (Golconda).

P. wapanuckensis Harlton (**280**—24, 25). **Penn.:** Okla. (Wapanucka, Johns Valley).

***P. humerosus** U and B (**280**—27–30). More convex than *P. nicklesi*; hinge line sunken from elevation of dorsal portion. **U. Penn., Perm.:** Kan. (Elmdale–Ft. Riley), Tex.

SCHMIDTELLA Ulrich 1892

(**S. crassimarginata*). Unsulcated shells, 2 mm or less long; short, subovate, broadly umbonate; most convex in dorsal region and pinched in ventral slope; right valve overlapping left ventrally. **Ord., Sil.; Penn.?**

***S. crassimarginata** Ulrich (**280**—35–37). Center of valve strongly elevated; surrounded by marginal depression. **Ord.:** Chazyan of N. Y. (Valcour); Stones River of Ala. (Lebanon); Black River of Wis. and Ill. (Platteville), Minn,

LEPERDITELLA Ulrich 1894

(**Leperditia rex* Coryell and Schenck, new name for *L. inflata* (Ulrich)). Left valve is larger and has a groove within ventral border into which simple edge of right valve is received; faint broad depression usually present in central part of dorsal half; length 1 to 3 mm. **Ord.–Dev.**

***L. rex** C and S (**280**—31). **M. Ord.:** Ky. (Ridley).

L. tumida (Ulrich) (**280**—32–34). **M. Ord.** (Lowville): Pa., Va., Ky., Tenn.

MACRONOTELLA Ulrich 1894

(**M. scofieldi*). Shell semicircular or semiovate with

a long, nearly straight hinge line; valves equal, inflated centrodorsally, without ridges or sulcus but exhibiting a smooth, subcentral spot where reticular ornamentation is lacking. **Ord.–Dev.**

***M. scofieldi** Ulrich (**280**—42–44). Hinge line forming greatest shell width; ends acute or rectangular; length one-half to one and three-fourths times height. **M. Ord.** (Black River): Ky., Minn.

M. rugosa (Jones) (**280**—41). **Trenton:** Ont.; N. Y., Minn. (Prosser), Ia. (Guttenberg, Ion).

SACCELATIA Kay 1940

(**Aparchites arrectus* Ulrich). Valves small, similar; outline deeply truncate elliptical; hinge straight, relatively long; ends subequal; valves quite convex, surface smooth or finely reticulate, having ventral swellings, flanges and projections in some species; contact with left valve overlapping; bordered by marginal granules in some species. **Ord.**

***S. arrecta** (Ulrich) (**280**—38–40). **Decorah:** Minn. (Ion).

CYATHUS Roth and Skinner 1930

(**C. ulrichi*). Shell small, canoe-shaped; valves with straight dorsal margin, marked along hinge line by V-shaped trough becoming a sharp ridge near ends, with no pronounced overlap; surface covered by concentric oscillating and bifurcating riblets. **L.** and **M. Penn.**

***C. ulrichi** R and S (**280**—45–48). **Des Moines:** Mo., Kan.

AECHMINA Jones and Holl 1869

(**A. cuspidata*). Straight-hinged, simply convex shells without pit or sulcus; with single, sometimes enormously developed, dorsolaterally directed, dorsomedian spine or hornlike process. **Ord.–Penn.**

A. ionensis Kay (**280**—54, 55). **Trenton:** Minn. (Ion).

A. richmondensis Ulrich and Bassler (**280**—51, 52). **U. Ord.:** Ind. (Elkhorn).

***A. cuspidata** J and H (**280**—53). **L. Dev.:** N. Y. (Indian Ladder), W. Va. (New Scotland), Tenn. (Birdsong).

A. bigeneris Swartz (**280**—60, 61). Possesses paraechminid pit and aechminid spines. **Dev.:** Pa. (Shriver).

PARAECHMINA Ulrich and Bassler 1923

(**Aechmina spinosa* Hall). Like *Aechmina*, but has a pit on posterior side of spine base and more or less well defined ridgelike elevation along free edge of valve. **Sil., Dev.**

***P. spinosa** (Hall) (**280**—49, 50). Spine strong, pointing upward, outward and forward, sometimes slightly bent; a rounded, thickened border surrounds free margins of valves, sometimes pitted. **M. Sil.:** Ont. (Rochester); N. Y. (Rochester), Md., Pa.

Other species: **P. abnormis** (Ulrich) from N. Y. (Rochester); **P. postica** Ulrich and Bassler, from Rochester of Md and Pa.

PRIMITIA Jones and Holl 1865

(**Beyrichia mandula*). Straight-backed, dorsally truncated suboval or subovate; valve surface rather regularly convex, with rather well marked but small vertical dorsomedian furrow without distinct nodes; contact without appreciable overlap; hinge relatively simple, though it may be a little thickened, with faint longitudinal grooves and ridges; no dimorphism known; many species. **Ord.–Perm.**

P. (**?Plethobolbina**) **lativia** Ulrich (**280**—58, 59). **U. Ord.** (Richmond): Anticosti (English Head); Mich., Ohio, Ind. (Whitewater); Man. (Strong Mountain).

P. seriata Stewart (**280**—56, 57). **M. Dev.:** Ohio (Silica).

PRIMITIELLA Ulrich 1894

(**P. constricta*). Small, straight-backed, equivalved shells with broad, undefined median depression mainly in dorsal half of valves and with narrow border; dimorphism usually present, and probably separates this genus from typical primitians. **Ord.–Dev.**

***P. constricta** Ulrich (**281**—1–4). **M. Ord.:** Ky. and Tenn. (Lowville), Minn. and Ia. (Decorah).

P. unicornis (Ulrich) (**281**—5–7). With short spine near posteroventral margin. **Ord.:** N. Y. (Canajoharie, Whetstone Bluff), Ohio (Trenton); Wales (Bala); Australia (Yeringian).

HALLIELLA Ulrich 1891

(**Primitia? sculptilis*). Carapace with broad sulcus and very coarsely reticulate surface which rises to greatest height in anterodorsal quarter; thick double border. **Ord.–Miss.?**

H. labiosa Ulrich (**281**—15–17). **M. Ord.:** Ont. (Hull); Minn. and Ia. (Prosser).

H. retifera Ulrich (**281**—14). Sulcus broader and hinge line relatively shorter than preceding; posterior end the more convex. **Dev.:** Ky. (Jeffersonville).

PYXIPRIMITIA Swartz 1936

(**P. ventriclefta* Swartz (**281**—8, 9), from Oriskany (Shriver) of Pa.). Like *Halliella*, but lacking definite border paralleling free margins; carapace has boxlike form resulting from flattening of surface. **Sil., Dev.**

MILLERATIA Swartz 1936

(**Beyrichia cincinnatiensis* Miller). Small, strongly unisulcate, essentially equivalved shells like *Primitia*, but differing in development of strong asymmetrical dorsal umbos. **Ord.**

***M. cincinnatiensis** (Miller) (**281**—10–13). **Richmond:** Mich., Ohio, Ind., Ia.

PERPRIMITIA Croneis and Gale 1938

(**P. robusta*). Like *Primitia*, but with valves deeply sulcate; right valve overlapping left partly or entirely along free margin and conspicuously along

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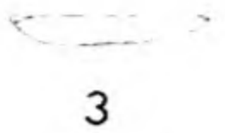
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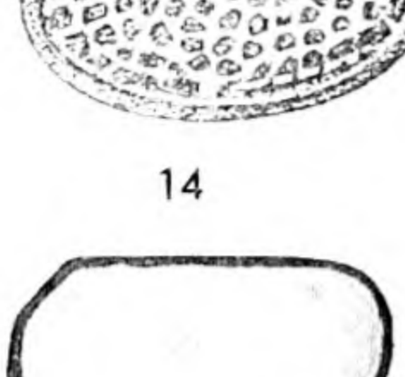
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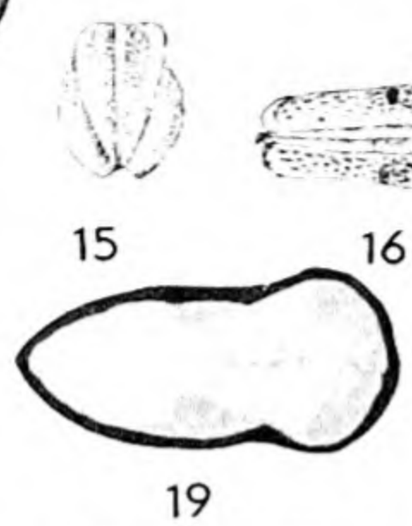
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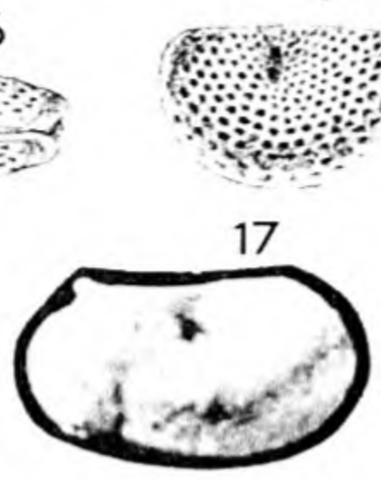
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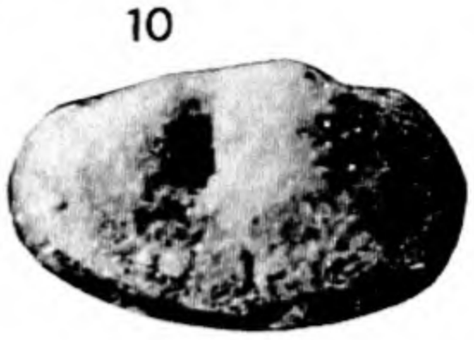
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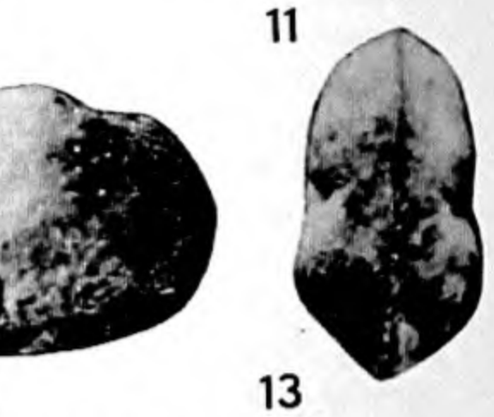
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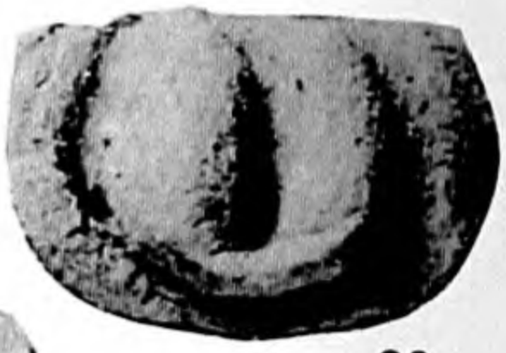
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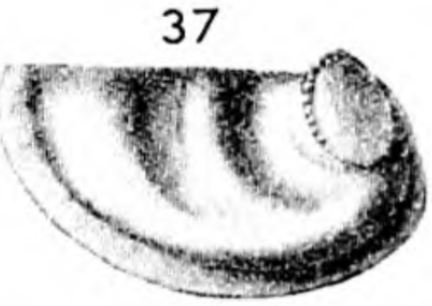
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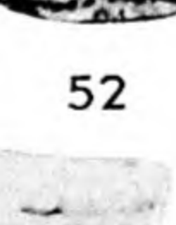
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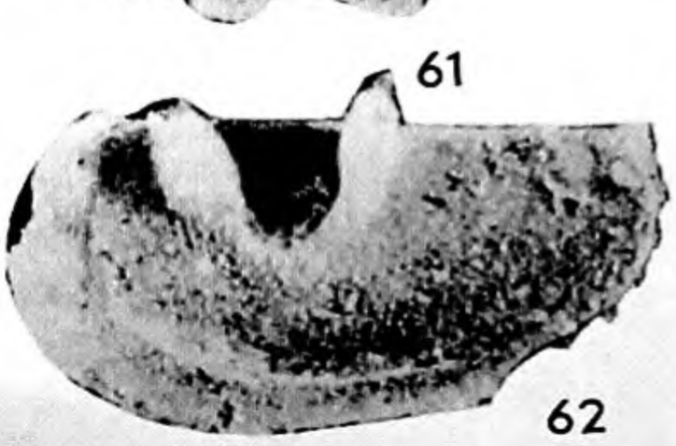
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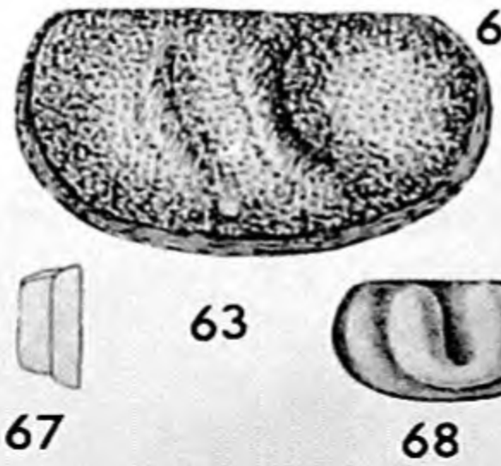
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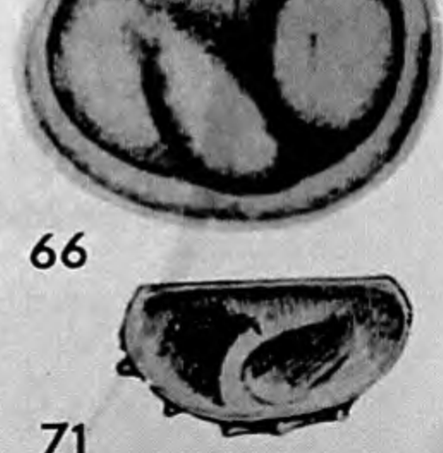
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venter; posterior lobe may be spine bearing, separated from anterior lobe by narrow groove. **U. Miss.**

***P. robusta** C and G (**281**—20). **Chester:** Ill. (Renault–Glen Dean).

P. funkhouseri Cooper (**281**—18, 19). **Chester:** Ill. (Kinkaid–Clore).

DREPANELLA Ulrich 1890

(**D. crassinoda*). Depressed convex, suboblong valves with more or less complete, often sickle-shaped sharply elevated marginal ridge, within which the surface exhibits two or more usually isolated nodes; ventral edge thick; brood pouch unknown, probably wanting. **M. Ord.**

***D. crassinoda** Ulrich (**283**—1–3). **Black River:** Va., Ind., Ky., Tenn.

JONESELLA Ulrich 1890

(**Leperditia crepidiformis*). Small, oblong or subovate, borderless shells distinguished by a U- or L-shaped ridge on posterior two-thirds. **U. Ord.**

***J. crepidiformis** (Ulrich) (**281**—21–23). **Cincinnatian:** Ont.; Ohio, Ky.

BOLLIA Jones and Holl 1886

(**B. bicollina*). Distinguished by centrally located looplike or horseshoe-shaped ridge, the free upper extremities of which are often bulbous; a more or less complete marginal ridge typically present, somewhat poorly developed or wanting. **Ord.–Dev.**

B. subaequata Ulrich (**281**—24–26). **M. Ord.** (Trenton): Ont.; N. Y., Minn., Ia.

B. regularis (Emmons) (**281**—27, 28). **U. Ord.** (Richmond): Mich., Ohio, Ind., Ky.

B. ungula Jones (**281**—33–35, 67–69). Small nodes at dorsal ends of limbs of inner U-shaped ridge; persistent flattening and angulation of marginal ridge. **Onondaga:** Pa. (Other reported occurrences must be confirmed.)

B. americana zygocornis Swartz (**281**—29–31). **Oriskany** (Shriver): Mid-Appalachian region.

B. burgeneri Swartz (**281**—32). **Oriskany:** Pa. (Shriver), Tenn. (Camden).

ULRICHIA Jones 1890

(**U. conradi*). Like *Primitia*, but has sharply defined node on each side of sulcus, which in this case is scarcely impressed; occasionally other nodes are present on ventral half of surface in some of questionable members of genus. **Ord.–Penn.**

***U. conradi** Jones (**281**—38). **Dev.:** Ont. (Hamilton); Mich. (Traverse), Ohio (Silica), Ky., Tenn. (Birdsong), Wis.

TETRADELLA Ulrich 1890

(**Beyrichia quadrilirata* Hall and Whitfield). Valves marked by four or less curved vertical ridges ventrally united; one or both inner ridges sometimes duplex; loculi or partitions usually project from posterior and posteroventral marginal ridge. **Ord.**

***T. quadrilirata** (H and W) (**281**—44, 45). **M. Ord.** (Black River): Ky., Tenn., Minn.; **U. Ord.** (Richmond): Ohio, Ind., Ky., Ia.

T. lunatifera (Ulrich) (**281**—39–43). **M. Ord.** (Trenton): Ky., Tenn., Minn., Ia.; **U. Ord.** (Richmond): Anticosti; Ohio, Ind., Ky.; Man.

CTENOLOCULINA Bassler 1941

(**Tetradella cicatricosa* Warthin). *Tetradella*-like shells with valves crossed transversely by four flat-topped, finely reticulated ridges separated by narrow furrows and with the margins surrounded by a false border, which in the female is swollen to form four to six loculi or brood chambers; right valve grooved on free margin to receive edge of left. **Dev.**

***C. cicatricosa** (Warthin) (**281**—36, 37). **M. Dev.:** Ont. and N. Y. (Hamilton), Mich. (Norway Point), Tenn. (Camden).

CERATOPSIS Ulrich 1894

(**Beyrichia chambersi* Miller). Differs from *Tetradella* by the remarkable process arising from dorsal extremity of posterior ridge; this may be straight and hornlike with one edge toothed, or expanded somewhat mushroomlike. **Ord., Sil.**

***C. chambersi** (Miller) (**281**—48–50). **M. Ord.:** Minn.; **U. Ord.:** N. Y. (Indian Ladder), Ohio (Eden).

PLATE 281

1–7. Primitiella spp. (x20) [Minn G S 3 (2)]. **1–4. P. constricta.** Two views of right valve; dorsal and side views. **5–7. P. unicornis.** Three views of a right valve. **8, 9. Pyxiprimitia ventriclefta** [JP 10]. Ventral and side views of genotype (x30). **10–13. Milleratia cincinnatiensis** (x37)[JP 10]. End view; interior and exterior of opposite valves; dorsal view. **14–17. Halliella** spp. **14. H. retifera** [Md G S, Sil]. Right valve of genotype (x20). **15–17. H. labiosa** [Minn G S 3 (2)]. Anterior, dorsal, and left side views (x20). **18–20. Perprimitia** spp. **18, 19. P. funkhouseri** [Ill G S, Rp Inv 77]. Side and dorsal views (x40). **20. P. robusta** [DUB, JSL 33]. Right valve (x30). **21–23. Jonesella crepidiformis** [Cin Soc N H, J 13]. Side, posterior, and ventral views (x20). **24–35. Bollia** spp. **24–26. B. subaequata** [JP 8]. Dorsal, ventral, and side views (x30). **27, 28. B. regularis** [USNM, Pr 35]. Ventral and side views (x30). **29–31. B. americana zygocornis** [JP 10]. Dorsal and side views (x15); surface of anterior knob of inner ridge (x45). **32. B. burgeneri** [JP 10]. Squeeze from external impression of right valve (x15). **33–35. B. ungula** (x25) [GSA, B 52]. Two squeezes from external impressions of left valves; external impression. **36, 37. Ctenoloculina cicatricosa** [JP 10]. Left side and ventral views of male (x29). **38. Ulrichia conradi** [Md G S, Sil]. Left valve (x30). **39–45. Tetradella** spp. [Minn G S 3 (2)]. **39–43. T. lunatifera.** Two valves (x22); three views of a left valve (x20). **44, 45. T. quadrilirata.** Posterior and side views of right valve (x20). **46–50. Ceratopsis** spp. **46, 47. C. oculifera** [USNM, Pr 35; 46 after Jones]. Left valve (x15); dorsal view of complete carapace (x18). **48–50. C. chambersi** (x20) [Minn G S 3 (2)]. Side and ventral views of left valve; right interior. **51, 52. Bellornatia tricollis** [JP 14]. Side and ventral views of holotype (x30). **53. Thomasatia falcicosta** [JP 14]. Left valve (x30). **54–57. Bassleratia typa** [JP 8]. Anterior, dorsal, ventral, and left side views of holotype (x30). **58–60. Raymondatia goniglypta** (x50) [JP 8]. Left side and dorsal views; left valve. **61, 62. Dicranella bicornis** [JP 14]. Ventral and right side views (x30). **63, 64. Ctenobolbina ciliata** [Cin Soc N H, J 13]. Left exterior and right interior (x18). **65. Dicranella bivertex** [Md G S, Camb and Ord]. Right valve (x20). **66. Ctenobolbina hammelli** [Ind G S 32]. Side view (x12). **67–69. Bollia ungula** [Md G S, L Dev]. Posterior, lateral, and ventral views (x20). **70, 71. Ctenobolbina loculata** [Cin Soc N H, J 19]. Right exterior and left interior (x20).

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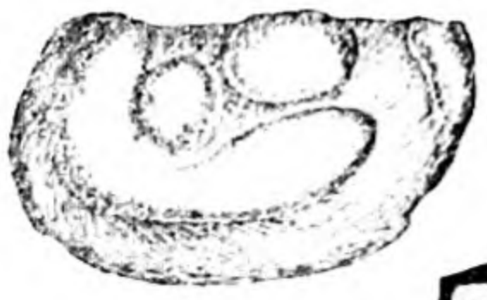
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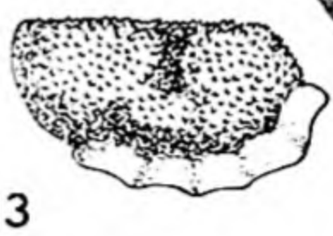
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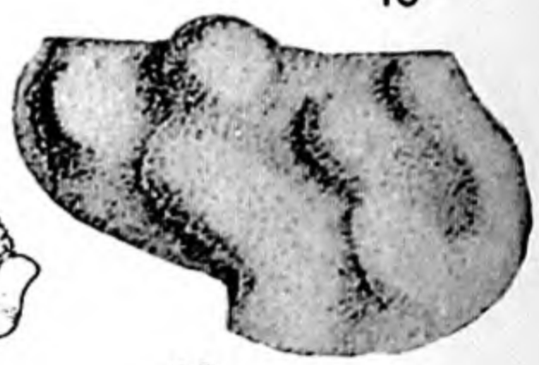
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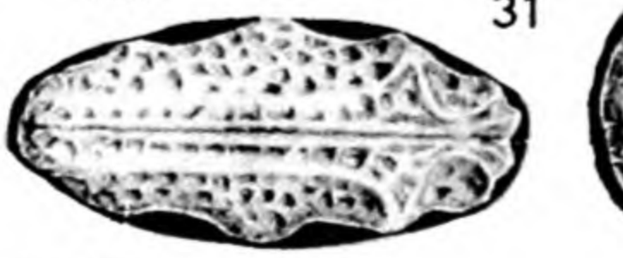
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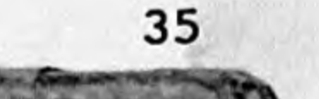
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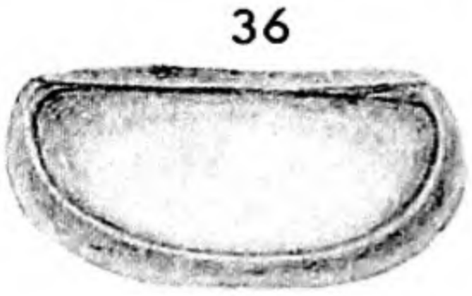
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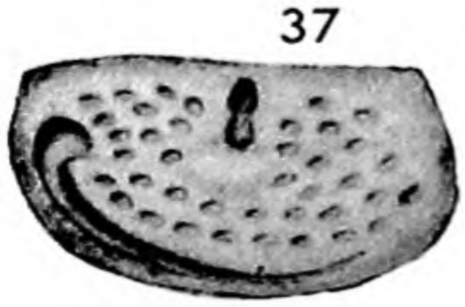
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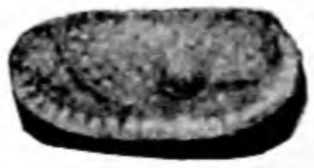
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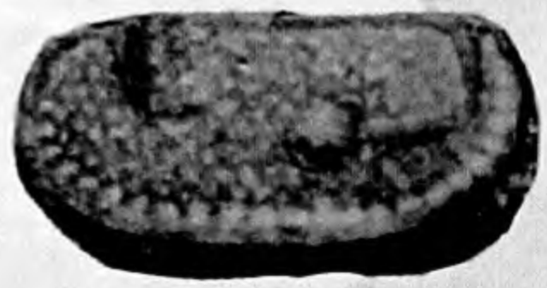
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C. oculifera (Hall) (**281**—46, 47). **U. Ord.:** Que.; N. Y. (Pulaski), Ohio (Corryville).

BELLORNATIA Kay 1934

(**B. tricollis*). Generic characteristics shown in illustrations of genotype. **Ord.**

***B. tricollis** Kay (**281**—51, 52). **Mohawkian:** Ont. (Hull); Ia. (Ion).

BASSLERATIA Kay 1934

(**B. typa*). Valves small, equal; outline subelliptical, dorsally truncated; dorsal margin straight, often with slight projection at posterior end; marginal ridge entire; similar ridge, more elevated, within it on free margins, within which are other ridges and nodes; contact obscured by overhanging margins, plane, without thickening. **Ord.**

***B. typa** Kay (**281**—54–57). **Mohawkian:** Ont. (Hull); Ia. (Ion).

THOMASATIA Kay 1934

(**T. falcicosta*). Valves small, equal; shell dorsally truncated; ends unequal, retral swing commonly obvious; marginal ridge on posterior and ventral; elevated ridge within on same borders, with distinct node within and just posterior to middle of valve; contact obscured by overhanging or carinate border, plane, without thickening. **Ord.**

***T. falcicosta** Kay (**281**—53). **Mohawkian:** Ont. (Hull); Minn. and Ia. (Decorah).

RAYMONDATIA Kay 1934

(**R. goniglypta*). Generic features shown by illustrations of genotype; classification uncertain. **M. Ord.**

***R. goniglypta** Kay (**281**—58–60). **Mohawkian:** Ont. (Hull); Wis., Minn., Ia.

DICRANELLA Ulrich 1894

(**D. bicornis*). Differs from *Ulrichia* in having one or both nodes developed into long, hornlike, diverging prominences and usually with a broad frill-like border along free edge of valves. **Ord.**

***D. bicornis** Ulrich (**281**—61, 62). Hornlike prominences diverging at an acute angle and rising above hinge line; a pronounced ridge parallels margin. **Black River:** Minn. (Decorah).

D. bivertex (Ulrich) (**281**—65). **Trenton:** N. Y. (Canajoharie), Pa. (Martinsburg), Ky. (Cynthiana).

CTENOBOLBINA Ulrich 1890

(**Beyrichia ciliata* Emmons). Straight-backed, typically with two, but in part with one, long subventral curving sulci dividing the surface into rather broadly convex lobes, and typically with rather inconspicuous submarginal frill along free edges. **Ord.–Miss.**

***C. ciliata** (Emmons) (**281**—63, 64). Posterior sulcus crescentic, narrow and deep; anterior shallower and narrower. **Ord.:** N. Y. (Trenton), Ohio (Eden); England (?Llandovery).

C. hammelli (Miller and Faber) (**281**—66). **U. Ord.** (Richmond): Anticosti (English Head); Ohio (Arnheim, Waynesville), Ind.

C. loculata Ulrich (**281**—70, 71). Deep, oblique sulcus with small posterior node behind it; frill lobate or subspinose. **Miss.:** Tenn. (Ridgetop), Mo. (Louisiana); Scotland (Lower limestone).

HOLLINELLA Coryell 1928

(**H. dentata*). Tapered edge of right valve fits into grooved hinge of left and protuberances near cardinal angles of right valve hinge with socket at their base, into which sockets corners of left valve fit; each species has three different forms: (1) with wide frill all along margin except at anterior; (2) with similar but narrower frill; and (3) with only a row of granules or spines representing frill. **Dev.–Perm.**

H. kolmodini (Jones) (**282**—1–3). Marginal frill obsolescent; thick curving ridge within posterior ventral border partly embraces minor lobe. **M. Dev.:** Falls of Ohio.

H. longispina (Jones and Kirkby) (**282**—5, 6). **Chester:** Ill. (Renault).

H. moreyi Croneis and Bristol (**282**—4). Has wide frill characteristic of most Mississippian species. **Chester:** Ill. (Golconda–Kinkaid).

H. radlerae (Harlton) (**282**—7–9). **Penn.:** Okla. (L. Glenn, Belle City), Tex. (Graham).

H. bassleri (Knight) (**282**—14, 15). **Penn.:** Neb. (Missouri), Mo. (Henrietta—Ft. Scott), Okla. (at numerous horizons), Tex. (Wayland).

H. emaciata (Ulrich and Bassler) (**282**—16–18). **Perm.:** Neb., Kan., Tex.

PARABOLBINA Swartz 1936

(**Ctenobolbina granosa* Ulrich). Carapace small, sublenticular in dorsal view; hingement apparently

PLATE 282

1–9. Hollinella spp. **1–3. H. kolmodini** [Cin Soc N H, J 13]. Dorsal, left side, and left interior views (x20). **4. H. moreyi** [DUB, JSL 34]. Right valve (x30). **5, 6. H. longispina** [Ill G S, Rp Inv 77]. Left valves showing broken spines on ventral margin (x20). **7–9. H. radlerae.** 7, 8: Dorsal and left side views (x26) [JP 2]. 9: Left interior showing grooved hinge (x30). **10. Kloedenia sussexensis** [USNM, Pr 35]. Side view (x10); also see **283**—40. **11, 12. Hollina insolens** [Cin Soc N H, J 19]. Left interior and exterior (x20). **13. Parabolbina granosa** [Cin Soc N H, J 19]. Left valve (x20). **14–18. Hollinella** spp. (x30) [JP 3]. **14, 15. H. bassleri.** Wide-frilled right valve — the holotype; frill-less right valve. **16–18. H. emaciata.** Left valve of narrow-frilled form; right valve of wide-frilled form; left valve of frill-less form. **19–25. Kirkbya** spp. **19. K. regularia** [DUB, JSL 33]. Left valve (x30). **20. K. marginata** [DUB, JSL 33]. Right valve (x35). **21. K. clarocarinata** [Am Mid Nat 13]. Right valve (x25). **22–25. K. canyonensis** [JP 7]. Two left and two right valves (x25). **26–42. Amphissites** spp. **26, 27. A. rugosus** [JP 7]. Two side views (x33). **28–30. A. carinatus.** [Ill G S, Rp Inv 77]. Dorsal, side, and end views (x30). **31. A. subquadratus** [Md G S, Sil]. Right valve (x20). **32–35. A centronotus.** Dorsal and side views (x45) [Am Mid Nat 14]; left and right valves (x30) [JP 7]. **36. A. dattonensis** [Am Mid Nat 14]. Left side view (x45). **37–39. A. roundyi** [JP 2]. Left valve (x55); right and left valves (x30). **40–42. A. girtyi** [JP 2]. Two left valves (x30); left valve (x55). **43–47. Kirkbyella** spp. **43, 44. K. bellipuncta** [JP 10]. Left interior and right exterior (x46). **45, 46. K. truncata** [Ill G S, Rp Inv 77]. Dorsal and left side views of holotype (x40). **47. K. typa** [Am Mid Nat 14]. Right valve (x50). **48. Balantoides quadrilobatus** [JP 9]. Left valve of holotype (x20). **49, 50. Ectodermites primus** [Ill G S, Rp Inv 77]. Left side and dorsal views of genotype (x30).

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simple; valve surface moderately and rather evenly convex, marked by faint median or slightly anterior sulcus; surface without true border, but provided with frill or spines near ventral edge; strongly granulose. **Dev.**

***P. granosa** (Ulrich) (**282**—13). **L. Dev.:** N. Y. (New Scotland).

HOLLINA Ulrich and Bassler 1908

(**Ctenobolbina insolens* Ulrich). Allied to *Ctenobolbina*, but posterior lobe is commonly broken up into three to four nodes of which the inner is most pronounced and most persistent; middle lobe terminated dorsally in large rounded node and anterior lobe is reduced to small node or is obsolete; marginal frill confined chiefly to posterior two-thirds; brood pouch undeveloped. **Dev.**

***H. insolens** (Ulrich) (**282**—11, 12). Marginal frill ending posterodorsally in rounded node, and continued upward from ventral end in curved ridge nearly to main node; another elongate node below posterior one, and a curved one in anterior end. **Onondaga:** Ky.

KIRKBYA Jones 1859

(**Dithyrocaris permiana*). Valves straight-hinged, arc-shaped, with angular cardinal extremities; hinge marked by toothlike protuberance under cardinal angles of left valve, or a more or less prominent ridge which fits into sockets on the right; submarginal flanges always present; overlap as in *Kellettina* and *Amphissites*; surface with polygonal reticulations and a subcentral pit or muscle spot, and often ornamented with nodes or ridges, the most prominent of which is the anterodorsal shoulder; shape and relative size of muscle spot constant within a species, hence important in specific identifications; many species. **Sil.–Perm.**

K. regularia Croneis and Gale (**282**—19). **Chester:** Ill. (Golconda).

K. marginata Croneis and Funkhouser (**282**—20). **Chester:** Ill. (Clore).

K. clarocarinata Knight (**282**—21). Muscle spot circular and relatively large. **Penn.:** Mo. (Ft. Scott), Kan. (Stanton), Okla. (Nowata), Tex. (Wayland).

K. canyonensis Harlton (**282**—22–25). **Penn., Perm.:** Kan. (Stanton-Wabaunsee; Elmdale, Neva), Tex. (Graham).

AMPHISSITES Girty 1910, emend Cooper 1941

(**A. rugosus*). Carapace with a single, centrally located node or swelling and two or more carinae or false keels, parallel or subparallel to free margins. **U. Miss.–Perm.**

A. subquadratus (Ulrich) (**282**—31). **M. Dev.** (Onondaga–Hamilton): Ont.; N. Y., Mich. (Bell, Thunder Bay), Ohio (Silica), Ky., Wis.

***A. rugosus** Girty (**282**—26, 27). **Chester:** Ill. (Kinkaid), Ark. and Okla. (Fayetteville).

A. carinatus Cooper (**282**—28–30). **Chester:** Ill. (Golconda, Glen Dean).

A. centronotus (Ulrich and Bassler) (**282**—32–35). Nearly symmetrical; marginal ridge sharp; a second more strongly curved ridge within, inclosing a central tubercle above the pit; surface finely reticulate. **U. Miss.–Perm.:** Ill., Neb., Mo., Kan., Okla., Tex. Colo.; Scotland. (Varieties reported from Ind. (Conemaugh) and Okla. (Nellie Bly).)

A. dattonensis Harlton (**282**—36). **Penn.:** Neb. (Missouri), Kan. (Kanwaka, Howard), Okla. (Deese–Holdenville), Tex. (Wayland, E. Mountain).

A. roundyi Knight (**282**—37–39). **Penn.:** Neb. (Missouri), Mo. (Ft. Scott), Okla. (Wewoka).

A. girtyi Knight (**282**—40–42). **Penn.:** Mo. (Ft. Scott), Okla., Tex. (E. Mountain).

KIRKBYELLA Coryell and Booth 1933

(**K. typa*). Carapace small, subquadrate to suboblong; hinge line straight; free margin bordered; valves apparently equal; pronounced subcentral sulcus extending up to near dorsal margin; surface reticulate; differs from *Kirkbya* in having a sulcus instead of a pit. **Dev.–Penn., Jura.?** (Morrison).

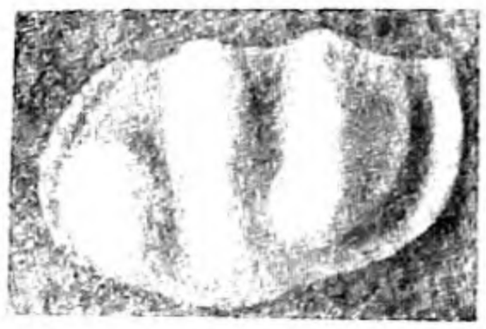
K. bellipuncta (Van Pelt) (**282**—43, 44). **M. Dev.:** Mich. (Bell), Ohio (Silica).

K. truncata Cooper (**282**—45, 46). **Chester:** Ill. (Menard).

***K. typa** C and B (**282**—47). **Penn.:** Tex. (Wayland).

PLATE 283

1–3. Drepanella crassinoda (x15) [Cin Soc N H, J 13]. Dorsal and right side views; posterior view of complete carapace. **4–7. Polytylites geniculatus** (x30) [Ill G S, Rp Inv 77]. 4, 5, 7: Posterior, left side, and dorsal views of genotype. 6: A somewhat smaller right valve. **8, 9. Savagella lindahli** [Cin Soc N H, J 13]. Side and ventral views (x10). **10. Polytylites directus** Ill G S, Rp Inv 77]. Side view of holotype (x40). **11. Kellettina robusta** [JP 10]. Left valve (x25). **12–14. Moorites** spp. **12. M. minutus** [Am Mid Nat 13]. Right valve (x45). **13, 14. M. convexus** [Ill G S, Rp Inv 77]. Right side and dorsal views of holotype (x50). **15, 16. Coelochilina** spp. (x18) [Cin Soc N H, J 13]. **15. C. aequalis.** Left valve. **16. C. striatomarginata.** Left valve. **17–22 Eurychilina** spp. [Minn G S 3 (2)]. **17–19. E. subradiata.** Left valve; right interior; section of 17 across central portion of valve. **20. E. reticulata.** Left valve (x20). **21, 22. E. ventrosa.** Side and end views of female? (x14). **23–33. Beyrichia** spp. **23–26. B. moodyi** (x15) [JP 10]. Side and ventral views of a male; ventral and side view of a female. **27, 28. B. contracta** [Ill G S, Rp Inv 77]. Side and dorsal views of holotype (x40). **29–31. B. sagitta** [Ill G S, Rp Inv 77]. Dorsal, side, and posterior views of holotype (x40). **32. B. tuberculata** [JP 4]. Side view (x10). **33. B. tonolowayensis** [Md G S, Sil]. Side view of type (x20). **34–36. Kloedenia normalis** (x12) [Md G S, Sil]. The two valves of a male; side view of a female carapace with a prominent brood pouch. **37, 38. Diboibina cristata** [Md G S, Sil]. Side views of male and female valves (x20). **39, 40. Kloedenia** spp. **39. K. ventralis** [Md G S, Sil]. Side view of valve showing transverse ventral elevation (x20). **40. K. sussexensis** [USNM, Pr 35]. Side view (x10); also see 282—10. **41–44. Zygobeyrichia** spp. (x12) [Md G S, Sil]. **41. Z. ventricornis.** Side view of a male. **42–44. Z. ventripunctata.** Female; male; female valve showing decided punctae on brood pouch. **45. Chiloboibina billingsi** [Md G S, Sil]. **46–50. Mastigoboibina** spp. **46. M. lata** [USNM, Pr 35]. Side view (x10). **47, 48. M. modesta** (x8) [Md G S, Sil]. Squeeze of a male valve; female valve. **49, 50. M. typus** [Md G S, Sil]. Male valve (var. **angulata**) (x6); female valve (x8).



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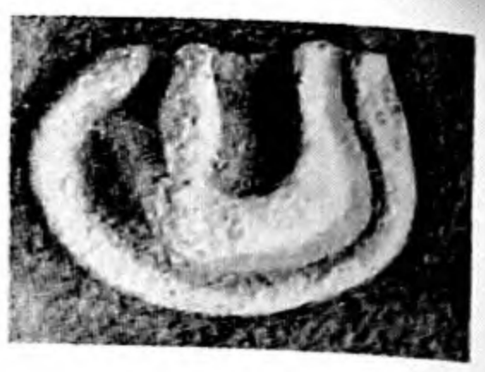

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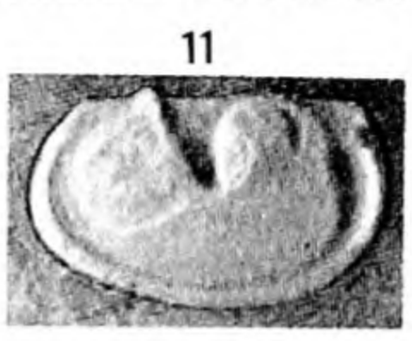

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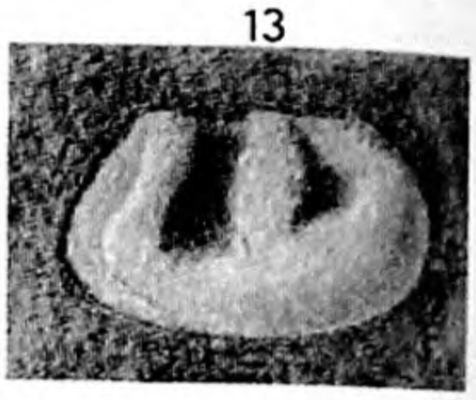

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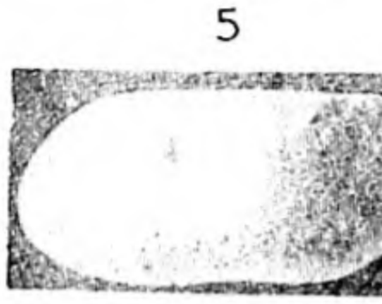

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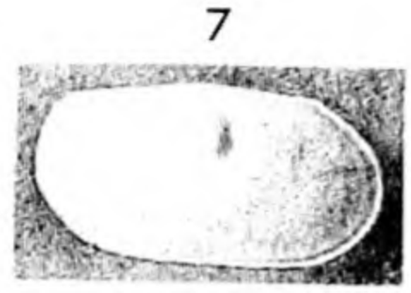

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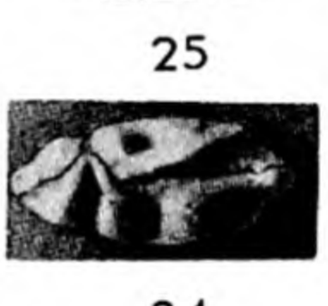

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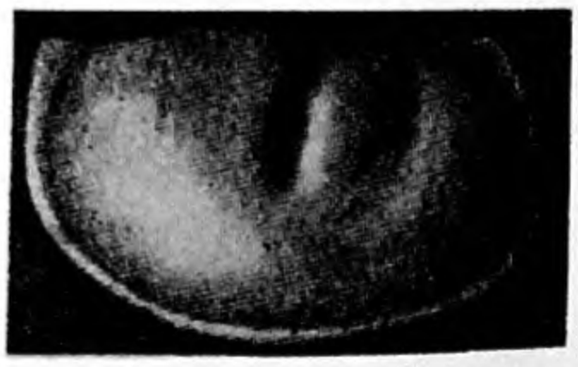

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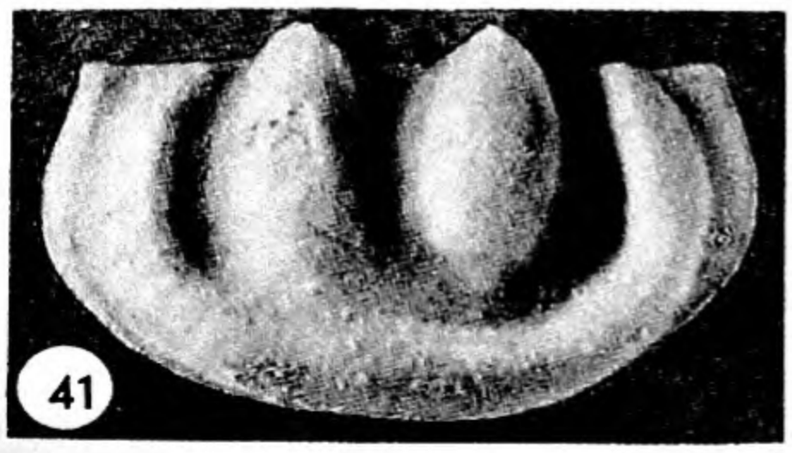

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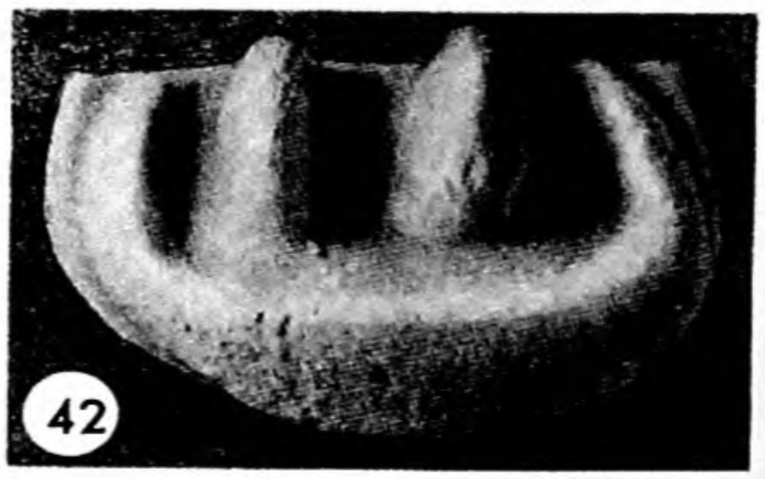

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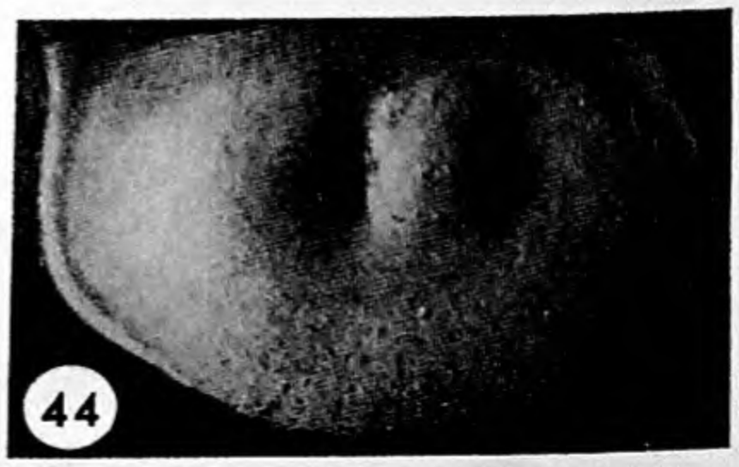

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BALANTOIDES Morey 1935

(**B. quadrilobatus*). Hinge structure like *Amphissites*; right valve overlaps left strongly on free edges; three lobes project to or above hinge, central most prominent; surface reticulate. **Miss.** (Ill., Wyo.).

***B. quadrilobatus** Morey (282—48). **Amsden:** Wyo.

ECTODERMITES Cooper 1941

(**E. primus*). Kirkbyid shells with regularly convex or inflated, ovate carapace, marked by one or more false keels but without well defined nodes; regularity of curvature often interrupted by slight swelling (not to be confused with central node of *Amphissites*) near central portion above pit. **Miss.**

***E. primus** Cooper (282—49, 50). **Chester:** Ill. (Kinkaid).

POLYTYLITES Cooper 1941

(**P. geniculatus*). Kirkbyid shells with central node and shoulders or swellings in dorsal extremities; if latter are short and prominent, carapace has trinodal appearance; surface marked by kirkbyan pit below central node and fine to coarse reticulations; one to two carinae parallel to free margin. **Miss., Penn.**

***P. geniculatus** Cooper (283—4–7). **Chester:** Ill. (Renault, Vienna).

P. directus Cooper (283—10). **Chester:** Ill. (Glen Dean).

KELLETTINA Swartz 1936

(**Ulrichia robusta* Kellett). Straight-hinged, elongate kirkbyan shells with angular cardinal extremities; left valve overlapping beveled outside edge of right, hingement fairly complex; two large and prominent nodes on upper half of valve distinguish genus, anterior one the larger; surface reticulated. **Penn., Perm.**

K. montosa (Knight). Differs from *K. robusta* in shorter nodes. **Penn.:** Mo., Neb., Okla.

***K. robusta** (Kellett) (283—11). **Perm.:** Kan. (Wreford).

SAVAGELLA Geis 1932

(**Kirkbya lindahli* Ulrich). Straight-hinged, oblong-rhomboidal shell; left valve narrowly overlaps right; surface coarsely reticulate except for smooth marginal band; large central pit; left hinge flanged to fit into grooved right valve. **Miss.**

***S. lindahli** (Ulrich) (283—8, 9). Strongly convex; pit pronounced. **Meramec:** Ind. (Salem), Ill. (Warsaw), Tex. (Barnett).

MOORITES Coryell and Billings 1932

(**M. hewetti = Glyptopleurina? minuta* Warthin). Shell minute, laterally subrectangular with straight hinge line and valves meeting evenly; surface with a slightly elevated marginal border and low, elongate, looplike costa, indistinct and branching in post-dorsal area, surface finely pitted except on costa and border. **Miss., Penn.**

M. convexus Cooper (283—13, 14). **Chester:** Ill. (Paint Creek).

***M. minutus** (Warthin) (283—12). **Penn.:** Neb. (Missouri), Mo. (Labette), Kan. (Stanton–Howard), Okla. (Wetumka–Holdenville; Deese, Hoxbar), Tex. (Wayland, E. Mountain).

COELOCHILINA Ulrich and Bassler 1923

(**Eurychilina aequalis* Ulrich). Straight-hinged with primitian sulcus and free margins bordered by wide, convex frill. **Ord.**

***C. aequalis** (Ulrich) (283—15). Shorter than *Eurychilina reticulata* and proportionately higher and more symmetrical; sulcus central; margin smooth, thick, rounded. **M. Ord.:** Ky. (Ridley), Tenn. (Lebanon).

C. striatomarginata (Miller) (283—16). Differs from preceding in slightly greater elongation and less prominent, finely striated marginal rim. **U. Ord** (Richmond): Ont. (Queenston); Ind., Ky.

EURYCHILINA Ulrich 1889

(**E. reticulata*). Oblong or semielliptical, long-hinged shells with a subcentral primitian sulcus, the posterior edge of which is often raised into a small, rounded node; free margins provided with a wide, usually radiately plicated, frill-like border curved on its under side so as to form a concave area around the true contact edge of valves. **Ord., Sil.**

***E. reticulata** Ulrich (283—20). **M. Ord.:** N. Y. (Rysedorph), Minn. (Black River, Decorah), Ia. (Decorah).

PLATE 284

[Figures are from Md G S, Sil, unless otherwise indicated.]

1, 2. Zygobolbina conradi. Female and male right valves (x8). **3, 4. Zygosella vallata.** Side view of male left valve (x8); slab with two male valves (x6). **5–10. Eukloedenella spp. 5–8. E. umbilicata** (x16). Dorsal, right side, and ventral views of complete carapace; left side view. **9, 10. E. sinuata** [JP 7]. Male and female right valves (x20). **11–14. Bonnemaia spp. 11, 12. B. celsa.** Ventral and side views of male right valve (x8). **13, 14. B. rudis.** Right valve of male (x8); left valve of female (x6). **15–18. Zygobolba spp. 15, 16. Z. decora** (x8). Two female right valves; right and left male valves. **17, 18. Z. bimuralis** (x8). Slab with three male valves variously tilted; typical male right valve. **19–30. Kloedenella spp. 19, 20. K. gibberosa.** Opposite side views of two specimens (x16). **21. K. nitida.** Right valve (x20). **22–24. K. pennsylvanica** [After Jones]. Left side, end, and ventral views (x15). **25, 26. K. macer** [Ill G S, Rp Inv 77]. Right side and dorsal views of holotype (x40). **27–30. K. nitida** (x20) [JP 7]. Right side view of male carapace; right side, ventral, and dorsal views of a complete female carapace. **31–37. Dizygopleura spp. 31–35. D swartzi.** 31, 32: Male and female right valves (x27) [JP 7]. 33, 35: Two carapaces viewed from opposite sides (x20). 34. Dorsal view of complete carapace (x20). **36, 37. D. symmetrica** (x20). One of the original types viewed laterally; dorsal view of complete carapace. **38–40. Kyammodes spp. 38, 39. K. tricornis.** Male and female right valves (x16). **40. K. swartzi.** Side view showing subpentagonal form and projecting ventral slope (x12). **41, 42. Drepanellina clarki.** Male and female left valves (x12). **43, 44. Welleria obliqua.** Male and female left valves (x12).

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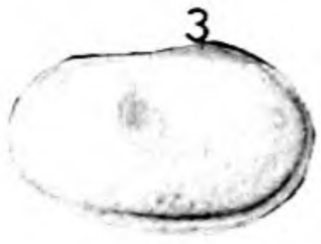
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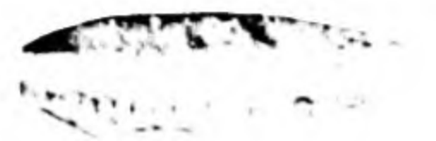
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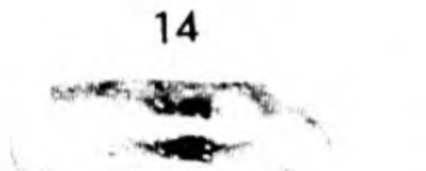
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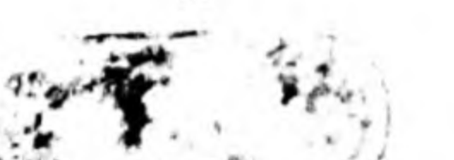
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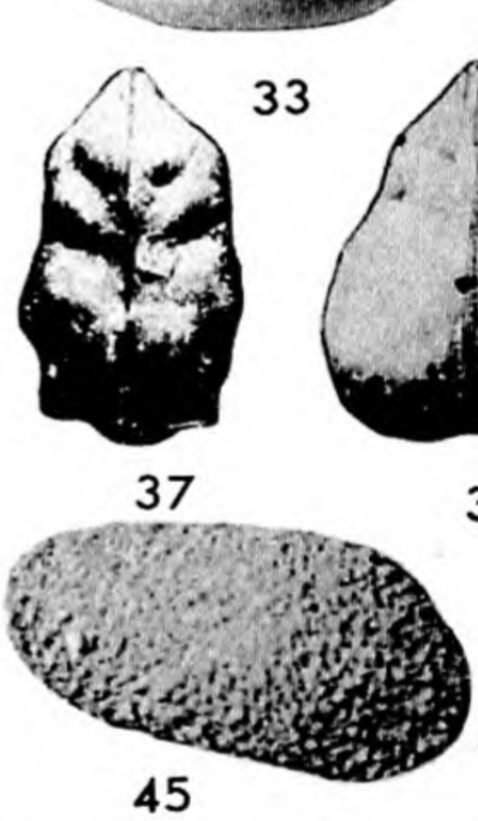
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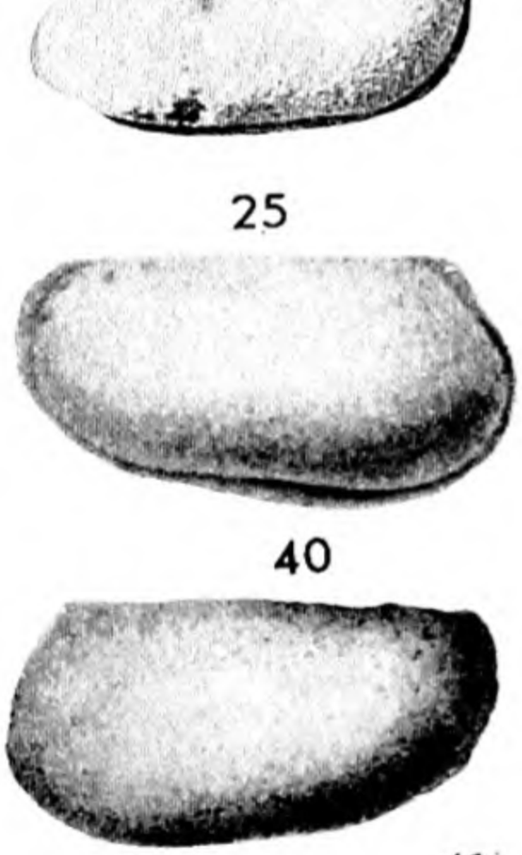
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E. subradiata Ulrich (**283**—17–19). **M. Ord.:** N. Y. (Canajoharie), Ind. and Ill. (Platteville), Tenn. (Stones River, Lebanon), Minn. (Decorah), Ia. (Decorah).

E. ventrosa Ulrich (**283**—21, 22). **M. Ord.:** Minn. (Trenton).

CHILOBOLBINA Ulrich and Bassler 1923

(**Primitia dentifera* Bonnema). Like *Coelochilina*, but differing in having a long, ovate brood pouch developed in posterior three-fifths of ventral part of frill. **Ord., Sil.**

C. billingsi (Jones) (**283**—45). Median pit well outlined; a curved impressed line between pit and frill base. **Sil.:** Anticosti (Gun River, Jupiter); Ont. (Dyer Bay); Md. (Clinton).

BEYRICHIA McCoy 1844

(**Agnostus* (*Battus*) *tuberculatus* Kloeden). Straight-backed, distinctly trilobate; middle lobe smallest, rounded and commonly isolated, posterior longer but also detached; brood pouch subglobular or ovate, ventroposterior or in Bonnema's opinion ventroanterior; many species. **Ord.–Penn.**

***B. tuberculata** (Kloeden) (**283**—32). **Sil.:** Europe.

B. tonolowayensis Ulrich and Bassler (**283**—33). **Cayugan** (Tonoloway): Mid-Appalachian region.

B. moodeyi Ulrich and Bassler (**283**—23–26). **Cayugan** (McKenzie): Mid-Appalachian region.

B. sagitta Cooper (**283**—29–31). **Chester:** Ill. (Paint Creek).

B. contracta Cooper (**283**—27, 28). **Chester:** Ill. (Golconda).

DIBOLBINA Ulrich and Bassler 1923

(**D. cristata*). Widely frilled, with trilobation of surface much obscured, only the middle lobe being definitely developed; brood pouch nearly hemispheric, mainly posterior in position. **Sil.**

***D. cristata** Ulrich and Bassler (**283**—37, 38). **Cayugan:** Md. and W. Va. (Tonoloway).

KLOEDENIA Jones and Holl 1886

(**Beyrichia wilckensiana* Jones). Straight-backed, subovate, rather obese shells with two subventral to dorsal sulci inclosing a rounded median lobe; other lobes broadly convex; free margins with narrow border; dimorphic, with ventroposterior, swollen, well defined brood pouches. **O. d.–Dev.**

K. ventralis (Ulrich and Bassler) (283—39). **Cayugan** (McKenzie): Mid-Appalachian region.

K. normalis Ulrich and Bassler (283—34, 35). **U. Sil.:** Md. (Wills Creek).

K. sussexensis (Weller) (282—40; 283—40). Anterior sulcus strong, posterior weak; marginal rim narrow; surface granulose; form elongate. **Dev.** (Helderberg): N. B. (Dalhousie); N. Y. (Decker Ferry), Md. (Keyser).

ZYGOBEYRICHIA Ulrich 1916

(**Z. apicalis*). Like *Kloedenia*, except that sulci are larger and posterior one extends to ventral border, leaving anterior and median lobes yoked together; brood pouch is also undefined on its inner side and larger. **Sil., Dev.**

Z. ventripunctata Ulrich and Bassler (**283**—42–44). **Cayugan:** Md. and W. Va. (Tonoloway).

Z. ventricornis Ulrich and Bassler (**283**—41). **Cayugan** (Tonoloway): Md., Mid-Appalachian region.

MASTIGOBOLBINA Ulrich and Bassler 1923

(**M. typus*). Large trilobate shells with narrow rim along free margins; posterior lobe narrow; anterior lobe large and irregularly shaped; median lobe pyriform, tapering below and passing in the most typical forms into a whiplashlike raised extension that turns obliquely forward and upward and then backward again across anterior lobe; dimorphic, the brood pouch large, terminoposterior in position, covering marginal rim and summit of posterior lobe, its inner side sharply defined by posterior sulcus. **M. Sil.**

M. lata (Vanuxem) (**283**—46). Posterior lobe slightly developed. **M. Clinton:** N. Y., Pa., Md., Va.

***M. typus** U and B (**283**—49, 50). **U. Clinton:** Pa. (Rose Hill), Md., Va., W. Va.

M. modesta Ulrich and Bassler (**283**—47, 48). **U. Clinton:** Pa. (Rose Hill).

PLATE 285

[Figures are from Ill G S, Rp Inv 77, unless otherwise indicated.]

1–4. Carboprimitia depressa. Dorsal, right side, posterior, and left side views (x20). **5–13. Sansabella** spp. **5–7. S. amplectans** [USGS, PP 146]. Left and right side and dorsal views of type (x25). **8–13. S. bradfieldi** (x30). Posterior, dorsal, and right side views of a reversed specimen; posterior, dorsal, and left side views of a normal specimen. **14, 15. Chesterella exuta** [DUB, JSL 34]. Dorsal and side views (x30). **16–19. Deloia serrata** [DUB, JSL 33]. Ventral, dorsal, left side, and right side views (x40). **20. Geisina gregaria** [USNM, Pr 30, 35]. Left valve (x30). **21, 22. Geisina arcuata** [JP 2]. Left and right valves (x30). **23. Denisonia cirrata.** Holotype, a right valve (x30). **24–39. Jonesina** spp. **24–27. J. craterigera.** Dorsal and left side views of a female carapace (x30) and a male carapace (x40). **28–31. J. bolliaformis** (x25) [JP 7]. Dorsal and right side views of a carapace; right side and left side views. **32–34. J. carbonifera** (x15) [USGS, B 436]. Dorsal view of complete carapace; large right valve; typical left valve. **35–39. J. minnekahtensis** (x35) [JP 10]. Side, ventral, and dorsal views of a male carapace; dorsal and ventral views of a female carapace. **40–46. Graphiodactylus** spp. **40–42. G. arkansanus** [USGS, PP 146]. Three views of type specimen (x25). **43–46. G. granopunctatus** (x20) [JP 10]. Right valve; left interior; left valve; right interior. **45–57. Glyptopleura** spp. **47. G. bristoli.** Left valve (x30). **48. G. decacostata** [DUB, JSL 33]. Right valve (x30). **49, 50. G. henbesti** [DUB, JSL 34]. Right side and dorsal views (x30). **51. G. resupinata** [DUB, JSL 34]. Left valve (x30). **52. G. coryelli** [Am Mid Nat 12]. Right valve (x20). **53–55. G. inopinata.** Posterior, dorsal, and left side views of a male carapace (x20). **56, 57. G. alvea.** Left side and dorsal views of holotype (x30). **58–60. Glyptopleurina** spp. (x30). **58, 59. G. iniqua.** Dorsal and right side views of holotype. **60. G. oehersi.** Left valve.

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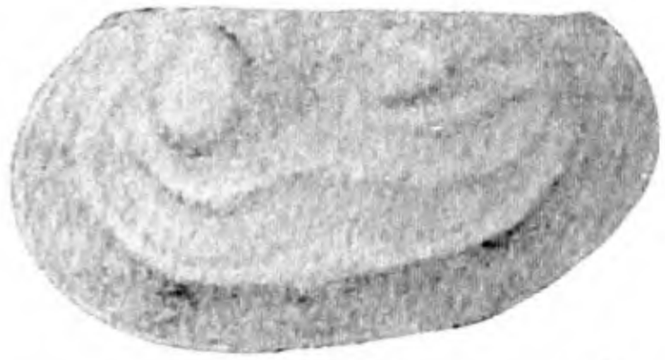
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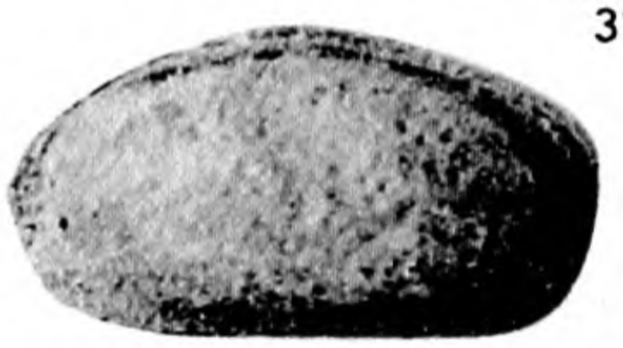
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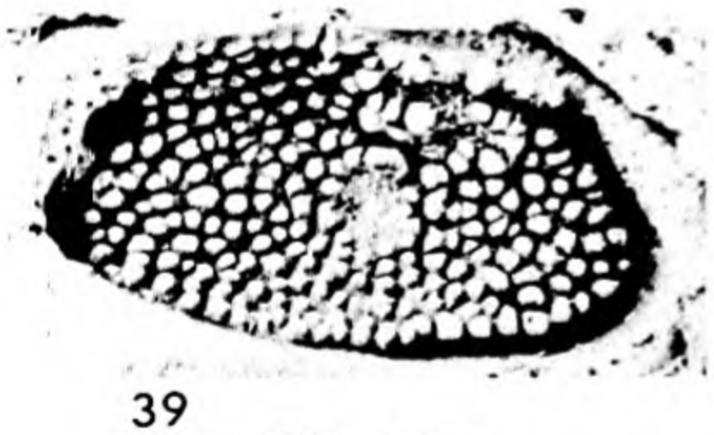
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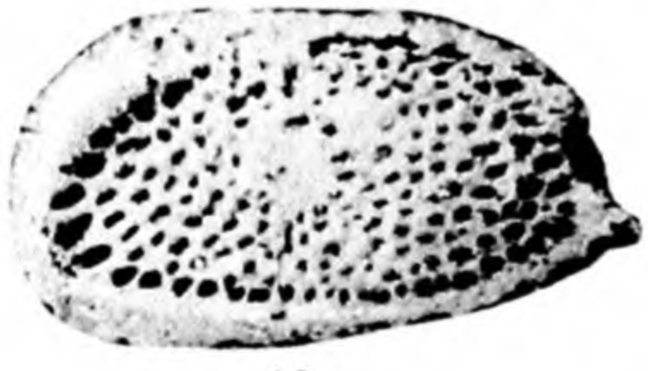
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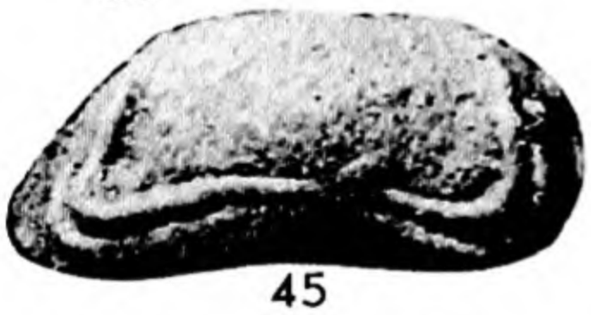
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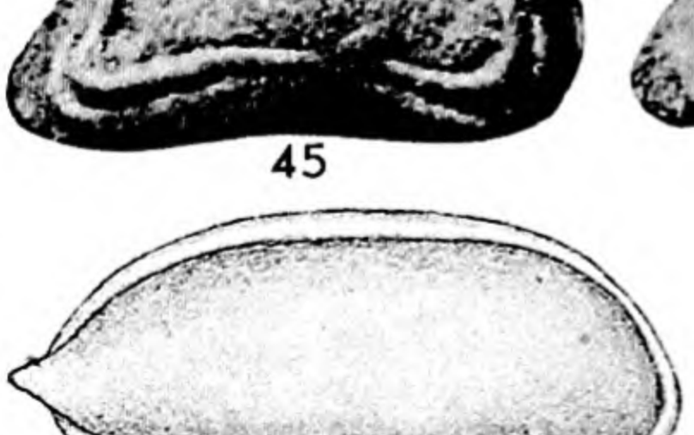
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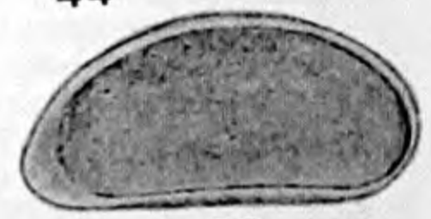
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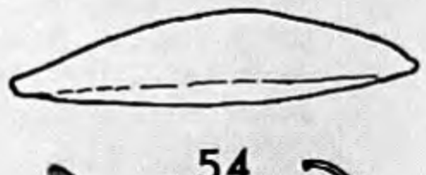
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KYAMMODES Jones 1888

(**K. whidbornei*). Like *Welleria*, but having two additional short sulci produced by incipient division of anterior and posterior lobes; brood pouch strongly convex, sharply defined, very large, covering nearly half the valve and projecting beyond border. **Ord.?, Sil., Dev.**

K. tricornis Ulrich and Bassler (**284**—38, 39). **Cayugan:** Md. (McKenzie).

K. swartzi Ulrich and Bassler (**284**—40). **Cayugan** (Tonoloway): Mid-Appalachian region.

WELLERIA Ulrich and Bassler 1923

(**W. obliqua*). Like *Kloedenia*, but brood pouch forms a low, broad, inwardly defined swelling affecting ventral half or two-thirds of valves and projecting slightly beyond the edge. **Sil., Dev.**

***W. obliqua** U and B (**284**—43, 44). **Cayugan:** (Tonoloway): Md., W. Va.

DREPANELLINA Ulrich and Bassler 1923

(**D. clarki*). Characterized by subventral dimorphic pouches which appear as indefinite swelling over ventrally confluent ridges; similarity to *Drepanella* in arrangement of knobs and marginal ridges apparently superficial and not indicative of genetic relationship. **Sil.**

***D. clarki** U and B (**824**—41, 42). **Clinton:** Md., Pa.

ZYGOBOLBA Ulrich and Bassler 1923

(**Beyrichia decora* Billings). Posterior lobe present but weak and brood pouch a well defined, acuminate-ovate swelling on outer two-thirds of postventral quarter. **Ord.–Dev.**

***Z. decora** (Billings) (**284**—15, 16). **M. Sil.** (Clinton): Anticosti (Jupiter): N. Y. (Williamson), Md. and Va. (Rose Hill).

Z. bimuralis Ulrich and Bassler (**284**—17, 18). **M. Clinton:** Md., Pa., Va., Tenn.

ZYGOBOLBINA Ulrich and Bassler 1923

(**Z. conradi*). Like *Zygobolba*, but larger, with posterior bulb usually nearly or quite obsolete, and brood pouch unequally bilobed **Sil.**

***Z. conradi** U and B (**284**—1, 2). **Clinton:** N. Y., Md., Va., Ga.

ZYGOSELLA Ulrich and Bassler 1923

(**Z. vallata*). Like *Zygobolba*, but brood pouch as a narrow, ridgelike elevation paralleling posterior border. **Sil.**

***Z. vallata** U and B (**284**—3, 4). **U. Clinton:** Pa., Md., Va., W. Va., Tenn.

BONNEMAIA Ulrich and Bassler 1923

(**B. celsa*). Very large shell with median sulcus short and U-shaped lobe thick, its posterior limb often divided in upper half by short posterior sulcus and anterior lobe usually crowned with sigmoidally curved angular crest; brood pouch large, indefinitely outlined on inner side, situated as in *Zygobolba*, in postventral quarter. **Sil.**

***B. celsa** U and B (**284**—11, 12). **U. Clinton:** Md., W. Va.

B. rudis Ulrich and Bassler (**284**—13, 14). **Clinton:** (Rose Hill), Mid-Appalachian region.

EUKLOEDENELLA Ulrich and Bassler 1923

(**E. umbilicata*). Valve surface evenly convex or with only a median pit or sulcus, and more rarely with shallow depression in ventral slope; dimorphic, females with posterior to postdorsal swellings. **Ord.–Dev.**

***E. umbilicata** U and B (**284**—5–8). **Cayugan:** Md. (McKenzie).

E. sinuata U and B (**284**—9, 10). **Cayugan:** Pa. (McKenzie).

KLOEDENELLA Ulrich and Bassler 1908

(**Kloedenia pennsylvanica* Jones). Like *Eukloedenella*, but valve surface with two prominent sulci; dimorphic. **Sil.–Miss.**

K. gibberosa Ulrich and Bassler (**284**—19, 20). **Cayugan** (McKenzie): Mid-Appalachian region.

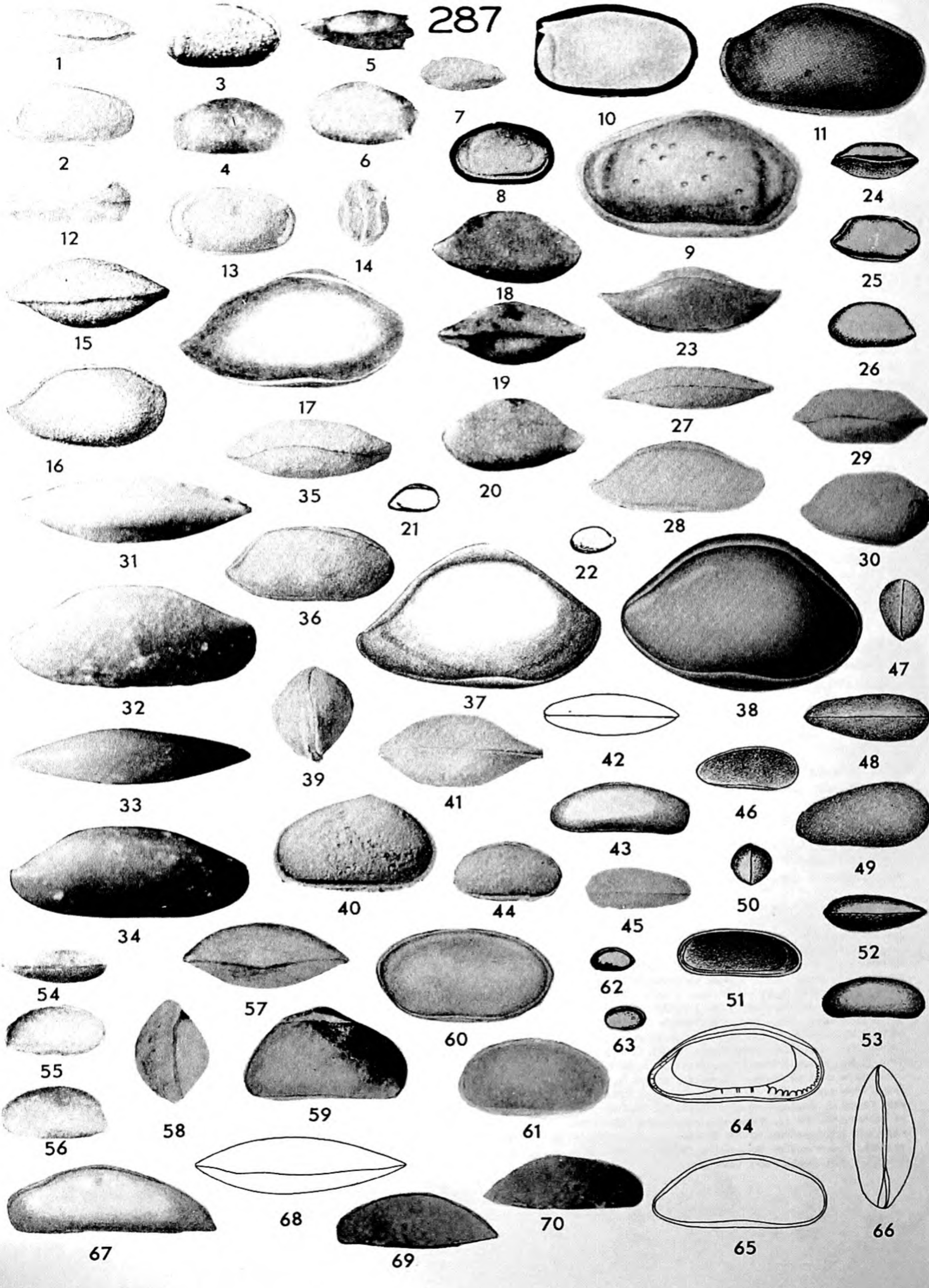
K. nitida Ulrich and Bassler (**284**—21, 27–30). **Cayugan** (McKenzie): Md., Pa.

***K. pennsylvanica** (Jones) (**284**—22–24). **U. Sil.:** Pa.; **L. Dev.** (Helderbergian): N. B. (Dalhousie).

K. macer Cooper (**284**—25, 26). **Chester:** Ill. (Glen Dean).

PLATE 286

1–6. Glyptopleurina (x30) spp. [Ill G S, Rp Inv 77]. **1–3. G. flexuosa.** Left side, dorsal, and posterior views of holotype. **4–6. G. longuronis.** Left valve (x18). **8, 9. Glyptopleurina** spp. **8. G. montifera** [JP 2]. Right valve (x50). **9. G.? bulbosa** [DUB, JSL 33]. Left valve (x30). **10, 11. Venula striata** [Ill G S, Rp Inv 77]. Dorsal and left side views (x30). **12–16. Thlipsura** spp. **12, 13. T. furca** [JP 3, 6]. Left side and dorsal views (x30). **14–16. T. confluens** (x15) [JP 6]. Left valve; right valve; dorsal view. **17–21. Thlipsurella** spp. **17, 18. T. secoclefta** [Wash Ac Sc, J 31]. Two right valves (x20). **19–21. T. ellipsoclefta** (x29) [JP 6]. Small right valve; side and dorsal views of right valve. **22. Glyptopleuroides insculptus** [DUB, JSL 33]. Right valve (x30). **23–31. Octonaria** spp. **23–25. O. stigmata.** Side and front views of right valve (x18) [Cin Soc N H, J 13]; right valve (x20) [USGS, B 508]. **26, 27. O. altoonensis** [JP 6]. Side and dorsal views of left valve (x29). **28, 29. O. deltisulcata** (x29) [JP 6]. Dorsal view of carapace; left valve. **30, 31. O. alticostata** [GSA, B 52]. Dorsal and side views of squeeze from external impression of left valve (x30). **32–36. Stibus kothornostibus** (x30) [GSA, B 52]. Holotype — external impression of right valve; two squeezes from external impressions of right valves; impression of left interior; squeeze from impression of a left exterior. **37–41. Favulella favulosa** (x30) [GSA, B 52]. Side view of left valve; impression of left interior; impression of left exterior; side views of two left valves. **42–44. Acanthoscapha** spp. **42, 43. A. pentagonalis** (x15) [JP 10]. Ventral view of carapace; side view of left valve. **44. A. navicula** [Md G S, Sil]. Interior view of valve (x20). **45–47. Ranapeltis trilateralis** (x30) [GSA, B 52]. Squeeze from holotype — an impression of a right exterior; impression of right and left interiors. **48–55. Krausella** spp. (x20) [Minn G S 3 (2)]. **48–50. K. inaequalis.** Three views of entire carapace. **51–55. K. arcuata.** Two views of the smaller (right) valve; left interior; ventral view of right valve; cross section of 53. **56. Beecherella carinata** [Md G S, Sil]. Right valve (x20).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DIZYGOPLEURA Ulrich and Bassler 1923

(**D. swartzi*). Differs from *Kloedenella* in having more or less distinct quadrilobation on valves, longer sulci, and prominent lobes at end bearing brood pouch (probably posterior); dimorphic. **Sil.–L. Miss.**

D. symmetrica (Hall) (**284**—36, 37). **M. Sil.:** N.Y. (Rochester), Md., Pa.

***D. swartzi** U and B (**284**—31–35). **Cayugan** (McKenzie): Md., Pa.

CARBOPRIMITIA Croneis and Funkhouser 1938

(**C. depressa*). Valves deeply sulcate, right overlapping left along free margin with ventral overlap conspicuous; free margin of right valve markedly bordered, dorsum tending to be flattened with hinge line marked by one to two offsets which may simulate a vague tooth and socket arrangement; dimorphic. **U. Miss.**

***C. depressa** C and F (**285**—1–4). **Chester:** Ill. (Glen Dean–Kinkaid).

SANSABELLA Roundy 1926

(**S. amplectans*). Shell small, left valve overlapping right along ends and ventral margin; hinge line straight, equal in both valves and slightly depressed below dorsal margins, giving channeled appearance; dimorphic. **Miss., Penn.**

***S. amplectans** Roundy (**285**—5–7). **Miss.:** Tex. (Marble Falls).

S. bradfieldi (Coryell and Sohn) (**285**—8–13). **Chester:** W. Va. (Reynolds), Ill., Ark. (Fayetteville).

CHESTERELLA Croneis and Gutke 1939

(**C. fissurata*). Valves subequal, sulcate just in front of midlength; pit ventrad of sulcus, outlined above and below by longitudinal ridges; surface granular, weakly pitted, or subreticulate. **U. Miss.**

C. exuta Croneis and Gutke (**285**—14, 15). **Chester:** Ill. (Renault).

DELOIA Croneis and Thurman 1938

(**D. serrata*). Shell with straight hinge line and serrated flanges along periphery; right valve overlaps left and occupies almost all if not all of area between flanges; sulcus anterior. **U. Miss.**

***D. serrata** C and T (**285**—16–19). **Chester:** Ill. (Kinkaid).

DENISONIA Croneis and Bristol 1939

(**D. cincta*). Characterized by straight hinge line, ridged dorsal outline, frilled border on free margin, and a strong rib dorsad to deep pit. **U. Miss.**

D. cirrata Cooper (**285**—23). **Chester:** Ill. (Golconda).

GEISINA Johnson 1936

(**Beyrichiella gregaria* Ulrich and Bassler). Right valve larger and overlapping left along ventral and end margins; sulcus slightly anterior to middle of dorsal half and there may be a faint sulcus in posterior half; hinge formed by overlap of left valve along anterior half of dorsal margin and a flange in posterior half of dorsal margin of left valve, which fits into corresponding groove in right valve; surface finely reticulate; dimorphic. **Penn.**

G. arcuata (Bean) (**285**—21, 22). **Penn.:** Que.; Mo. (Henrietta–Ft. Scott), Okla. (L. Glenn, Dornick Hills); England; Scotland.

***G. gregaria** (U and B) (**285**—20). **Penn.** (Kansas City): Neb., Kan., Mo., Okla.

JONESINA Ulrich and Bassler 1908, emend Cooper 1941

(**Beyrichia fastigiata* Jones and Kirkby). Carapace ovate, somewhat elongate, thin to obese, greatest thickness posterior; valves unequal; overlap around entire free margin usually prominent; variously lobed; hinge straight, obscurely cardine, about two-thirds total shell length; median sulcus opening into cardinal area, usually deep and elongate, before which occur one or more fairly well defined lobes; surface smooth or reticulate. **Miss.**

J. craterigera (Brady) (**285**—24–27). **Chester:** Ill. (Homberg).

J. bolliaformis (Ulrich and Bassler) (**285**—28–31). Nodes distinct, small, connected basally by a trans-

PLATE 287

1–6. Healdia spp. 1, 2. H. vinitaensis [Ill G S, Rp Inv 77]. Dorsal and side views (x40). **3. H. triangularis** [DUB, JSL 33]. Right valve (x30). **4–6. H. limacoidea** [JP 2]. Right side, dorsal, and left side views (x30). **7–9. Seminolites spp. 7, 8. S. sohni** [DUB, JSL 34]. Right side and dorsal views (x30). **9. S. truncatus** [Am Mid Nat 13]. Right valve (x50). **10, 11. Healdia spp.** [Am Mid Nat 13]. **10. H. cuneata.** Right valve (x65). **11. H. simplex.** Right valve (x55). **12–14. Tetratylus ellipticus** [Ill G S, Rp Inv 77]. Dorsal, left side, and posterior views of type (x40). **15–38. Bairdia spp. 15, 16. B. magnacurta** [JP 10]. Dorsal and right side views (x20). **17. B. oklahomaensis** [JP 1]. Left valve (x30). **18–20. B. citriformis** [JP 2]. Right side, dorsal, and left side views (x30). **21, 22. B. glenrosensis** [JP 2]. Right and left valves (x12). **23. B. summacuminata** [Am Mus Nov 891]. Right valve (x25). **24–26. B. cestriensis** [Cin Soc N H, J 13]. Dorsal, right side, and left side views (x14). **27, 28. B. attenuata** [Ill G S, Rp Inv 77]. Dorsal and side views (x20). **29, 30. B. aequa** [Ill G S, Rp Inv 77]. Dorsal and side views of holotype (x30). **31–34. B. reussiana** [JP 8]. Dorsal and right side views of two specimens (x30). **35, 36. B. sinuosa** [Ill G S, Rp Inv 77]. Dorsal and right side views of holotype (x30). **37. B. alexandrina** [U Tex B 2907]. Right valve (x42). **38. B. suborbiculata** [JP 8]. Right valve (x37). **39–66. Bythocypris spp. 39–41. B. truncata** [Ill G S, Rp Inv 77]. Posterior, right side, and dorsal views of holotype (x30). **42, 43. B. goodlandensis** [U Tex B 2907]. Dorsal and right side views (x42). **44, 45. B. clorensis** [Ill G S, Rp Inv 77]. Right side and dorsal views (x40). **46–49. B. cylindrica** [Minn G S 3 (2)]. Right interior, posterior, dorsal, and left side views (x20). **50–53. B. subaequata** [Md G S, Eoc]. Anterior, left interior, dorsal, and right side views (x10). **54–56. B. pediformis** [JP 2]. Dorsal, right side, and left side views (x30). **57–59. B. (Bairdocypris) morrisonensis** [JP 7]. Dorsal, posterior, and right side views (x10). **60. B. indianensis** [JP 10]. Right valve (x29). **61. B. tomlinsoni** [Am Mid Nat 13]. Right valve (x60). **62, 63. B. rotundus** [JP 2]. Right exterior and interior (x12). **64–66. B.? gibsonensis** [La G S, GB 7]. Interior, left valve, and dorsal views (x30). **67–70. Macrocypris spp. 67, 68. M. graysonensis** [U Tex B 2907]. Left side and dorsal views (x42). **69, 70. M. menardensis** [U Tex B 2901]. Left side and right side views (x25).

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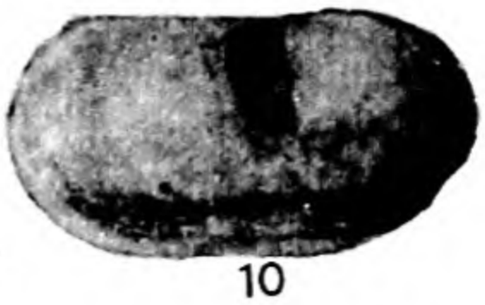
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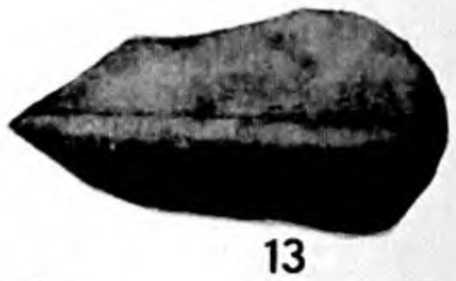
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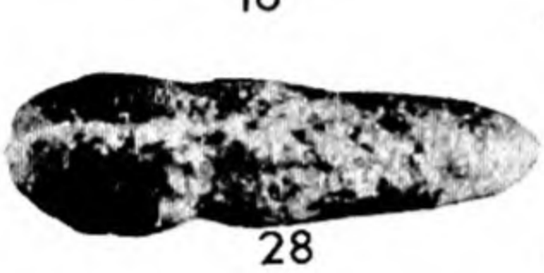
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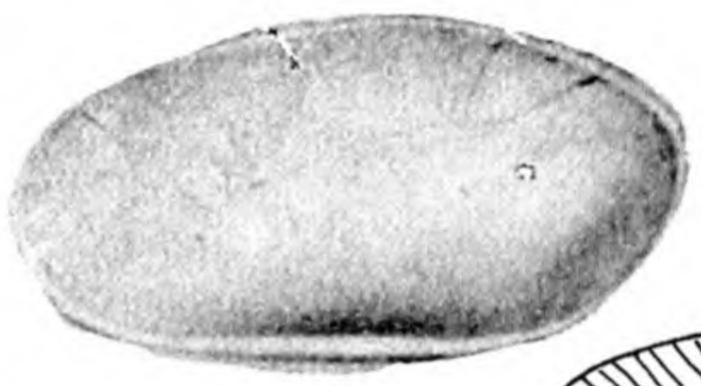
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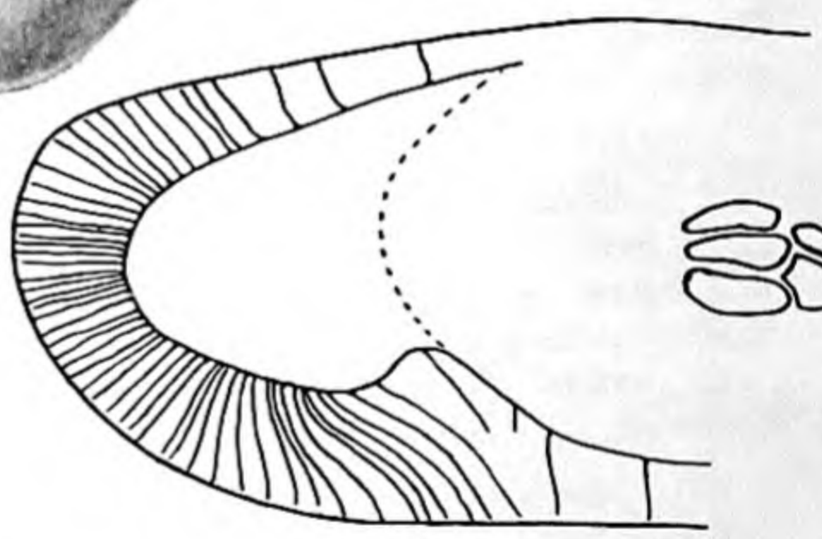
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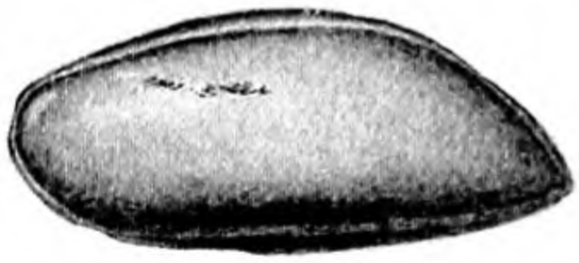
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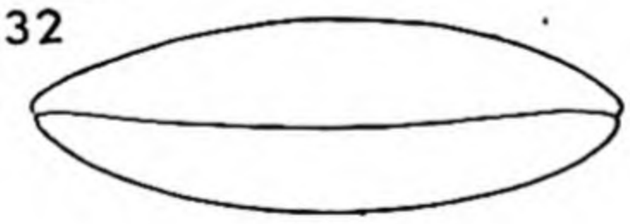
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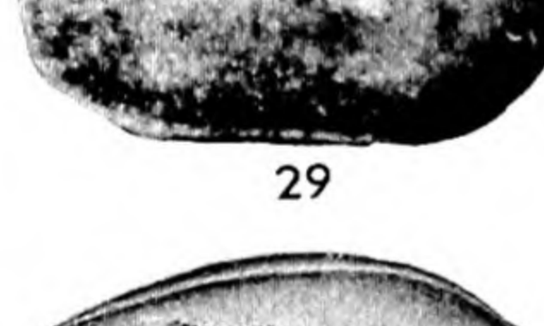
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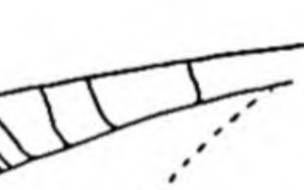
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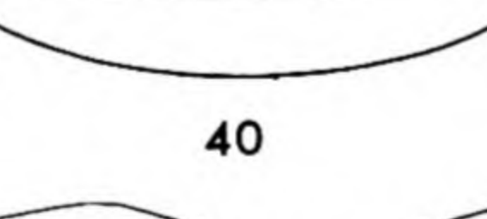
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verse ridge, with a second broad poorly defined ridge below this. **Penn., Perm.:** Neb. (Cottonwood), Kan. (Wabaunsee–Chase), Tex.

J. carbonifera Girty (**285**—32–34). **Perm.:** Wyo.

J. minnekahtensis Roth (**285**—35–39). **U. Jura.:** S. Dak. (Morrison).

GRAPHIODACTYLUS Roth 1929

(**Kirkbya lindahli arkansana* Girty). Shell subrectangular, with pronounced backward swing; individual species range from short and tumid to long and slim; valvular overlap pronounced, right valve being completely rabbeted on all margins to receive the left; right valve very prominently overlaps left in region of cardinal angles, thereby concealing cardinal teeth of left valve; surface ornamented. **Dev.–L. Penn.**

***G. arkansanus** (Girty) (**285**—40–42). **L. Miss.–L. Penn.:** Ark. and Okla. (Fayetteville), Tex. (Barnett).

G. granopunctatus (Ulrich and Bassler) (**285**—43–46). **Miss.:** Tenn. (Ridgetop), Mo. (Chouteau).

GLYPTOPLEURA Girty 1910

(**G. inopinata*). Shell subquadrate with straight hinge line, left valve overlapping right; surface with median pit and sculptured with inosculating costae. **Miss.–Perm.**

G. henbesti Croneis and Gutke (**285**—49, 50). **Chester:** Ill. (Renault).

G. decacostata Croneis and Gale (**285**—48). **Chester:** Ill. (Golconda).

G. resupinata Croneis and Bristol (**285**—51). **Chester:** Ill (Menard).

***G. inopinata** Girty (**285**—53–55). **Chester:** Ill. (Clore), Ark. (Fayetteville, Pitkin).

G. alvea Cooper (**285**—56, 57). **Chester:** Ill. (Kinkaid).

G. coryelli Harlton (= **G. spinosa** Harlton). (**285**—52). **Penn.:** Neb. (Missouri), Tex. (Graham).

G. bristoli Croneis and Gutke (**285**—47). **Chester:** Ill. (Renault, Paint Creek).

GLYPTOPLEURINA Coryell 1928

(**G. montifera*). Differs from other glyptopleurids in having nodes and a marginal flange of extremely variable nature; right valve larger and overlapping; greatest thickness and ventral truncation posterior; obtuse cardinal angle anterior. **Miss., Penn.**

G. oehersi (Croneis and Bristol) (**285**—60). **Chester:** Ill. (L. Elvira).

G. iniqua Cooper (**285**—58, 59). **Chester:** Ill. (Vienna).

G.? bulbosa Croneis and Gale (**286**—9). **Chester:** Ill. (Golconda, Glen Dean).

G. flexuosa Cooper (**286**—1–3). **Chester:** Ill. (Paint Creek).

G. longuronis Cooper (**286**—4–6). **Chester:** Ill. (Renault).

***G. montifera** Coryell (**286**—8). **Penn.:** Okla. (Boggy).

VENULA Cooper 1941

(**Primitiopsis? striatus* Croneis and Funkhouser) Like *Glyptopleura*, with subquadrate outline, faint anastomosing costae and characteristic hingement; right valve larger, overlapping around free margin; pit small, circular, almost midway between ends and slightly above midheight. **U. Miss.**

***V. striata** (C and F) (**286**—10, 11). **Chester:** Ill. (U. Elvira).

GLYPTOPLEUROIDES Croneis and Gale 1938

(**G. insculptus*). Like *Glyptopleura*, but ribs are broader, inclosed along free margin by wide border, and given their relief by grooves between them. **U. Miss.**

***G. insculptus** C and G (**286**—22). **Chester:** Ill. (Golconda–Menard).

EUGLYPHELLA Warthin 1934

(**Strepula sigmoidalis* Jones). Carapace subtriangular in lateral view, greatest height in posterior half; hinge line straight, inconspicuous; each valve bears a C-shaped carina, opening anteriorly; anterior end spinose. **Dev.** (Helderbergian–Hamilton) (Ont.; N. Y., Mich., Ohio, Mo.).

***E. sigmoidalis** (Jones) (**286**—7). **M. Dev.:** Ont.; N. Y. (Ludlowville), Mich. (Bell, Gravel Pt.) (var **primitiva** Warthin reported from Mich. (Gravel Pt.) and Ohio (Silica)).

THLIPSURA Jones and Holl 1869

(**T. corpulenta*). Valves convex with right over-

PLATE 288

1–5. Pontocypris spp. **1–3. P. arcuata** [Md G S, L Dev]. Dorsal, right side, and posterior views (x20). **4, 5. P. perforata** [JP 2]. Left and right valves (x12). **6, 7. Tubulibairdia tubulifera** (x15) [JP 10]. Impression of left interior; left exterior. **8, 9. Bairdiolites crescentis** [DUB, JSL 33]. Right side and dorsal views (x30). **10–13. Beyrichiopsis thori** [JP 13]. Left side, right side, dorsal, and ventral views (x30). **14–18. Acratia** spp. **14–16. A. tumida** [Ill G S, Rp Inv 77]. Right side, dorsal, and ventral views (x30). **17, 18. A. typica** [JP 4]. Ventral and right side views (x20). **19, 20. Bairdiolites fornicatus** [Ill G S, Rp Inv 77]. Two views of holotype (x30). **21–23. Cribroconcha fornicata** [Ill G S, Rp Inv 77]. Posterior, dorsal, and right side views of holotype (x40). **24. Sulcella sulcata** [Am Mid Nat 13]. Left valve (x30). **25–27. Condracypris simplex** [JP 3]. Three views of a specimen (x20). **28–34. Cavellina** spp. **28, 29. C. glandella** [JP 6]. Left side and dorsal views (x22). **30, 31. C. parallela** [Ill G S, Rp Inv 77]. Dorsal and left side views (x30). **32. C. pulchella** [Am Mid Nat 13]. Left valve (x25). **33, 34. C. nebrascensis** [JP 9]. Side and dorsal views of holotype (x40). **35–38. Barychilina punctostriata** [Cin Soc N H, J 13]. Right side, left side, dorsal, and posterior views (x10). **39–41. Argilloecia faba** [JP 8]. Left valve and dorsal view (x95); left valve by transmitted light, showing inner margin (reconstructed), line of concrescence, radial pore canals, and muscle scars (x250). **42–51. Cytherella** spp. **42–45. C. hiwanneensis** [La G S, GB 7]. Dorsal and left side views of male and female respectively (x40). **46, 47. C. ovata** [U Tex B 2907]. Dorsal and left side views (x42). **48–51. C. mariboroensis** [Md G S, Eoc.]. Dorsal, right side, left side, and right interior views (x20). **52–54. Paracypris** spp. **52. P. perapiculata** [JP 8]. Right valve (x40). **53, 54. P. weatherfordensis** (x12) [JP 2]. Left exterior and right interior. **55–58. Ponderodictya bispinulata** [Am Mus Nov 891]. Dorsal view (x25); interior of a right valve (x25); two right valves (x20).

lapping left and with region bordering anterior margin depressed to form well defined sunken area with one to two furrows opening from this area and extending back for some distance. **Sil., Dev.**

T. furca Roth (**286**—12, 13). **L. Dev.:** Tenn. (Birdsong), Okla. (Haragan).

T. confluens Swartz (**286**—14–16). **Oriskany:** Pa. (Shriver).

THLIPSURELLA Swartz 1932

(**T. ellipsoclefta*). Valves smaller than in *Thlipsura*, with right overlapping left but with surface most convex in front of middle; with short, nearly vertical submedian furrow; usually with two longitudinal pits in anterior half; sometimes a pit in posterior part. **Sil., Dev.**

***T. ellipsoclefta** Swartz (**286**—19–21). **Oriskany:** Pa. (Shriver).

T. secoclefta Swartz (**286**—17, 18). **Oriskany:** Pa. (Shriver), Tenn. (Camden).

OCTONARIA Jones 1887

(**O. octoformis*). Similar to *Thlipsurella*, but distinguished by tendency of left valve to overlap right, and by having surface of valves raised into a thin spiral or ringlike ridge, which in more typical forms resembles the figure 8. **Ord.–Dev.**

O. stigmata Ulrich (**286**—23–25). Outer ringlike ridge inclosing several others of less regular outline. **Dev.:** Ky. and Pa. (Onondaga), N. Y. (Hamilton).

O. altoonensis Swartz (**286**—26, 27). **Helderbergian:** Pa. (Keyser).

O. deltisulcata Swartz (**286**—28, 29). **Oriskany:** Pa. (Shriver).

O. alticostata Swartz and Swain (**286**—30, 31). **Onondaga:** Pa.

STIBUS Swartz and Swain 1941

(**S. kothornostibus*). Subreniform in outline with dorsal margin broadly arched; valve surface convex, with steep, concave posterior slope; one or more furrows, or rows of pits, in anterior portion, and usually numerous small pits in posterior region. **Dev.** (Pa., W. Va.).

***S. kothornostibus** S and S (**286**—32–36). **Onondaga:** Pa., W. Va.

FAVULELLA Swartz and Swain 1941

(**Bythocypris favulosa* Jones). Characterized by subreniform outline and marginal flange which incloses a strongly punctate area near the center of which is a smooth spot; subterminal spines; left valve apparently overlaps right along ventral margin but not at ends. **Dev.**

***F. favulosa** (Jones) (**286**—37–41). **Onondaga:** Pa., W. Va.

RANAPELTIS Bassler 1941

(**R. typicalis*). Shell subtrapezoidal to subreniform in outline; valve surface convex, ventral slope steep; two narrow surface ridges paralleling ventral margins and with ends bent dorsally. **Dev.** (Pa., W. Va., Tenn.).

R. trilateralis Swartz and Swain (**286**—45–47). **Onondaga:** Pa.

KRAUSELLA Ulrich 1894

(**K. inaequalis*). Valves unequal, left overlapping right dorsally and ventrally; posterior extremity of smaller (right) valve prolonged into a prominent spine. **Ord., Sil.**

***K. inaequalis** Ulrich (**286**—48–50). **Ord.:** Ill. (Platteville), Ia. (Maquoketa).

K. arcuata Ulrich (**286**—51–55). Valves moderately convex; spine blunt; anterior end sharply rounded. **M. Ord.** (Black River): Ind., Ill. and Wis. (Platteville), Ky. (Lowville), Minn. and Ia. (Decorah), Okla. (Bromide); England (?Llandovery); Northern Shan States.

ACANTHOSCAPHA Ulrich and Bassler 1923

(**Beecherella navicula* Ulrich). Similar to *Beecherella*, but anterior end is spineless and rounded in outline, while posterior spine is formed by prolongation of ventral edge instead of outer carina, which may be wanting entirely; within posterodorsal region true contact edge is set some distance within outer edge of valves. **L. Dev.**

***A. navicula** (Ulrich) (**286**—44). **L. Dev.:** N. Y. (New Scotland).

A. pentagonalis Swartz (**286**—42, 43). **Oriskany:** Pa. (Shriver)

BEECHERELLA Ulrich 1891

(**B. carinata* Ulrich (**286**—56), from **L. Dev.** (New Scotland) of N. Y.). Shell elongate, boat-shaped, triangular in transverse section, the ventrum being flat and carinated on its outer edges; ventral carinae prolonged at each end into spines, the anterior one short and small, the posterior much larger; hinge apparently simple and ventral edge of right valve seems to overlap left sharply. **Dev.**

HEALDIA Roundy 1926

(**H. simplex*). Laterally subtriangular to subelongate shell; left valve larger and with distinct groove for reception of right, overlapping it on all sides, although only slightly on dorsoposterior slope; surface smooth or punctate with two backward-pointing spines; an elevated ridge or shallow semicircular sinus on posterior smooth area of each valve. **Miss.–Perm.**

H. triangularis Croneis and Gale (**287**—3). **Chester:** Ill. (Golconda).

H. vinitaensis Harlton (**287**—1, 2). **Chester:** Ill. (Vienna).

H. limacoidea Knight (**287**—4–6). **Penn.:** Neb. (Missouri), Mo. (Des Moines), Okla. (Wewoka, Nowata, Bird Creek), Tex. (Wayland, E. Mountain).

***H. simplex** Roundy (**287**—11). **Penn.:** Kan. (Stanton, Kanwaka), Tex. (Wayland).

H. cuneata Coryell and Billings (**287**—10). **Penn.:** Kan. (Shawnee), Tex. (Wayland).

SEMINOLITES Coryell 1928

(**S. truncatus*). Left valve overlaps right along entire margin; surface marked by large circular pits and curved ridge near each end. **Miss., Penn.**

S. sohni Croneis and Bristol (**287**—7, 8). **Chester:** Ill. (Golconda, Menard).

***S. truncatus** Coryell (**287**—9). **Penn.:** Okla. (Nowata, ?Deese), Tex. (Wayland).

TETRATYLUS Cooper 1941

(**T. ellipticus*). Outline cytherelloid, sulcus primitian, hingement simple; differs from *Seminolites* in that the ridge, when present, is on and not back of the end margins of the shell, in the presence of four spines or knobs, and presence of a sulcus; from *Healdia* in having anterior spines and sulcus. **Miss.**

***T. ellipticus** Cooper (**287**—12–14). **Chester:** Ill. (Paint Creek).

BAIRDIA McCoy 1844

(**B. curta*). Shell subtriangular or rhomboidal, with greatest height near middle; inequivalved; narrowly rounded anteriorly and pointed posteriorly; generally smooth; dorsal margin rather strongly convex; hingement formed by a groove in each of interlocking valves; over 200 species, some of which may belong to BAIRDOPPILATA Coryell, Sample and Jennings 1935 (**B. martyni*). **Ord.–Recent.**

B. summacuminata Coryell and Malkin (**287**—23). **M. Dev.:** Ont. (Hamilton).

B. magnacurta Morey (**287**—15, 16). **L. Miss.:** Mo. (Chouteau).

B. cestriensis Ulrich (**287**—24–26). **Chester:** Ill. (Renault–Menard), Ky., Ark. (Boone).

B. aequa Cooper (**287**—29, 30). Characterized by flat parallel sides. **Chester:** Ill. (Renault).

B. attenuata Cooper (**287**—27, 28). **Chester:** Ill. (Glen Dean).

B. sinuosa Cooper (**287**—35, 36). **Chester:** Ill. (Kinkaid–Clore).

B. citriformis Knight (**287**—18–20). **L. Penn.:** Mo. (Pawnee).

B. oklahomaensis Harlton (**287**—17). **L.** and **M. Penn.** (Missouri): Central Interior; Colo., Tex.

B. reussiana Kirkby (**287**—31–34). **Perm.:** Neb., Kan.

B. glenrosensis Vanderpool (**287**—21, 22). **L. Cret.** (Trinity): La. (Glen Rose), Ark., Tex. (Glen Rose, Weatherford).

B. alexandrina Blake (= **B. subdeltoidea** (Muenster) of Alexander) (**287**—37). **U. Cret.:** Tex. (Eagle Ford). (Numerous specimens formerly referred to this "form species" are now known to belong to other species.)

B. suborbiculata Alexander (**287**—38). **Paleoc.:** Tex. (Midway).

B. subdeltoidea (Muenster). **Olig.:** Ala. (Red Bluff).

BYTHOCYPRIS Brady 1880

(**Bairdia bosquetiana* Brady, probably = *Bythocypris reniformis* Brady). Shell smooth, reniform, ovate or elliptical; left valve larger than right, overlapping it usually on both dorsal and ventral margins; dorsal margin convex, ventral edge straighter, sometimes slightly convex; over 125 species. (Paleozoic species are doubtfully referred to this genus.) **Ord.–Recent.**

B. cylindrica (Hall) (**287**—46–49). Valves nearly equal; ends broadly rounded. **Ord.** (Trenton–Richmond): Anticosti; N. Y., Ohio, Ind., Ky., Minn. (Decorah), Ia.; Man.

B. indianensis Ulrich (**287**—60). **L. Dev.:** Ohio (Silica), Ky. (Onondaga), Tenn. (Birdsong).

B. truncata Cooper (**287**—39–41). **Chester:** Ill. (Renault).

B. clorensis Croneis and Funkhouser (**287**—44, 45). **Chester:** Ill. (Kinkaid–Clore).

B. tomlinsoni Harlton (**287**—61). Dorsal border curved, ventral nearly straight; left valve overlapping right. **L. Penn.:** Okla. (Dornick Hills), Tex. (Wayland).

B. pediformis Knight (**287**—54–56). **L. Penn.–Perm.:** Neb. (Missouri; Perm.), Mo. (Des Moines), Kan. (Penn., Perm.), Okla. (Wetumka–Seminole), Tex. (Wayland), E. Mountain).

B. (Bairdocypris) morrisonensis Roth (**287**—57–59). **Jura.:** S. Dak. (Morrison).

B. goodlandensis Alexander (**287**—42, 43). Elongate; dorsal and ventral margins subparallel; length 0.61 mm. **L. Cret.** (Fredericksburg): Tex. (Goodland).

B. rotundus Vanderpool (**287**—62, 63). **L. Cret.** (Trinity): La., Ark., Tex.

B. subaequata Ulrich (**287**—50–53). **Eoc.:** Md. (Aquia).

B. ? gibsonensis Howe and Chambers (**287**—64–66). **Eoc.–Mioc.** (L. Jackson–L. Chickasawhay): Gulf Coast.

MACROCYPRIS Brady 1867

(**Cythere minna* Baird). Carapace more elongate than *Bythocypris* and with right instead of left valve the larger, and overlapping along dorsal margin; surface smooth; hinge structure simple, hinge teeth lacking. **Ord.–Recent.**

M. menardensis Harlton (**287**—69, 70). **Penn.:** Neb. (Missouri), Kan. (Stanton), Okla. (Nowata), Tex. (Graham).

M. graysonensis Alexander (**287**—67, 68). **L. Cret.** (Washita): Tex. (Grayson).

PONTOCYPRIS Sars 1865

(**P. serrulata*). Like *Bythocypris*, except that shell is very delicate and hinge is simple without overlap. **Ord.–Recent.**

P. arcuata Ulrich and Bassler (**288**—1–3). **L. Dev.:** Md. (Keyser).

P. perforata Vanderpool (**288**—4, 5). **L. Cret.** (Trinity): La., Ark., Tex.

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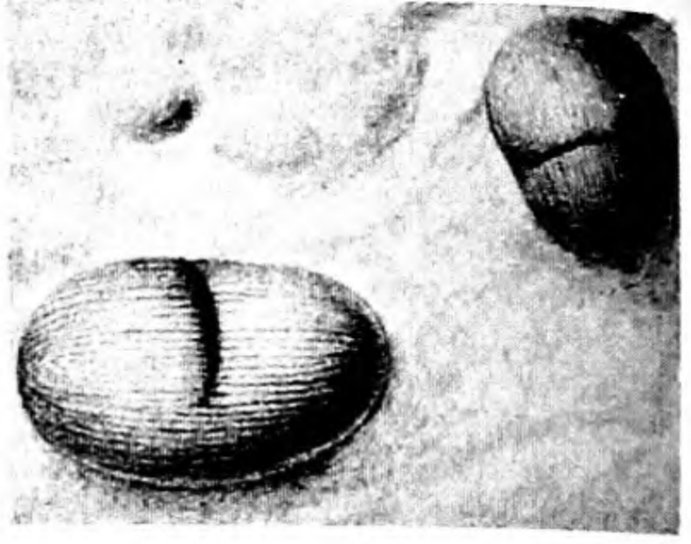
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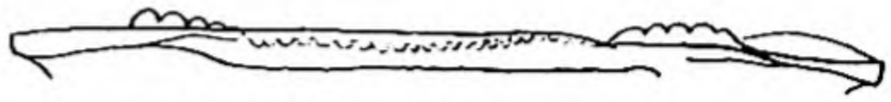

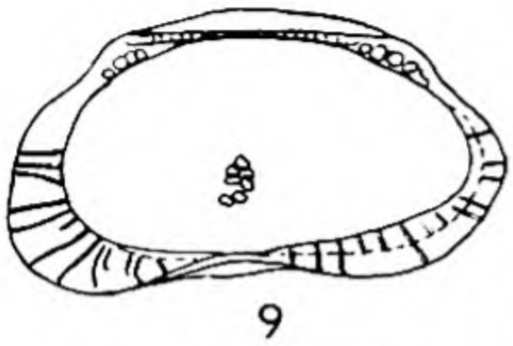
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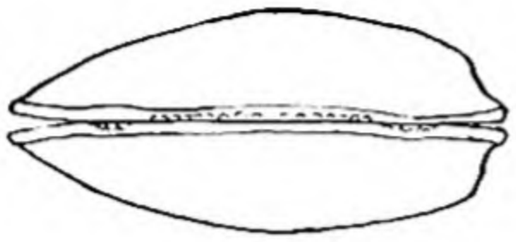
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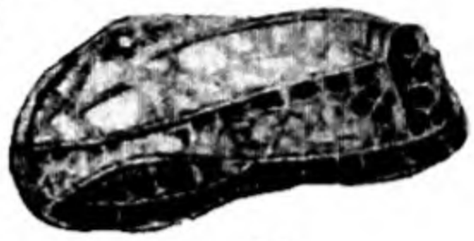

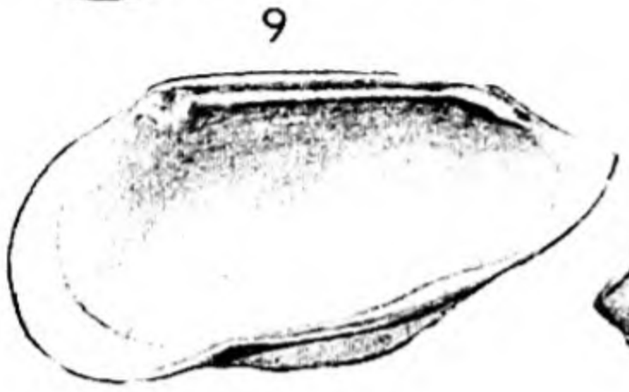
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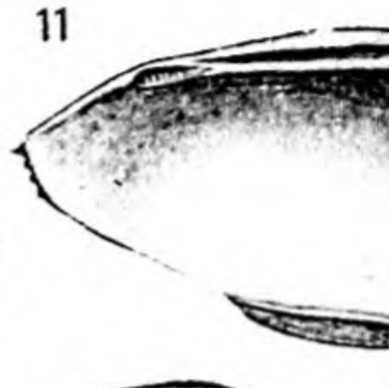
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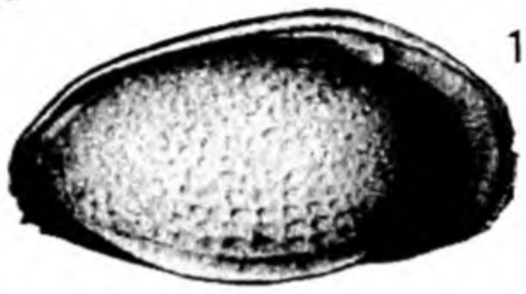
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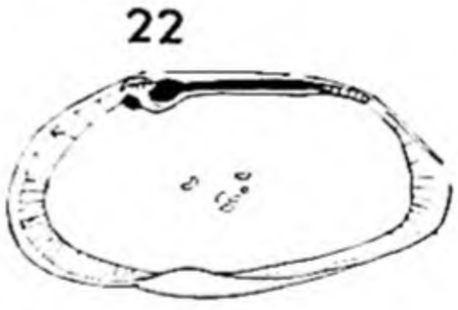

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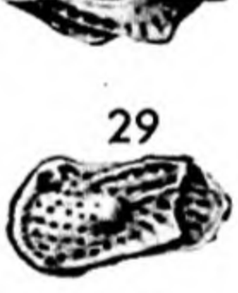
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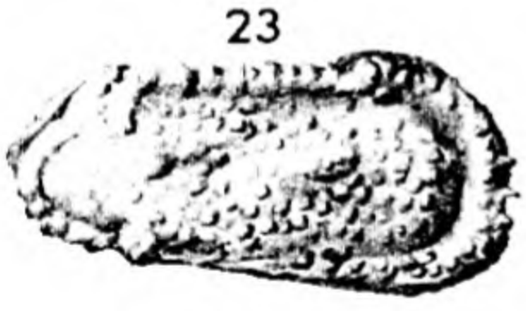

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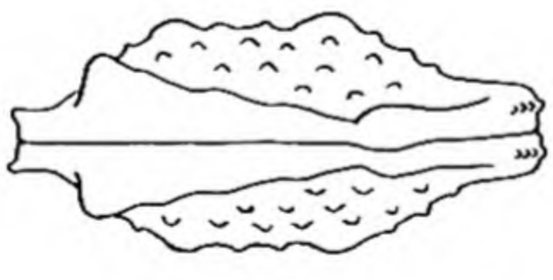

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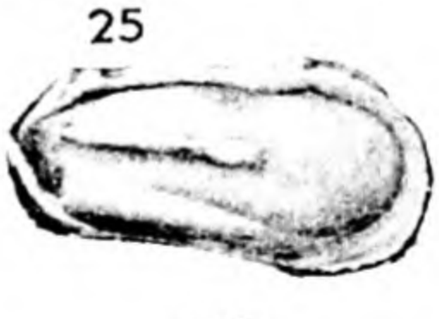

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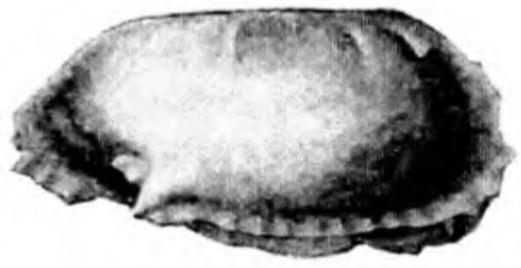

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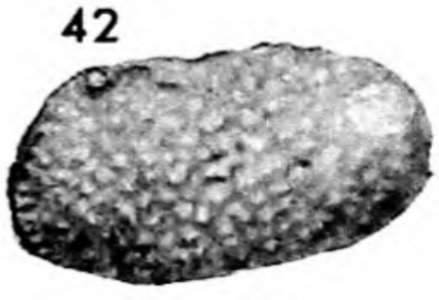

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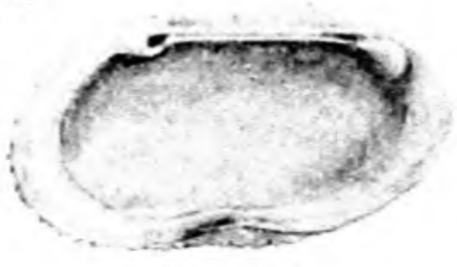

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TUBULIBAIRDIA Swartz 1936

(**T. tubulifera* Swartz (**288**—6, 7), from **Oriskany** (Shriver) of Pa.). Carapace subovoid in side view, posterior margin obtusely angulated; strongly inequivalved, with left valve larger and overlapping right along free margins and projecting above it dorsally; carapace smooth externally, but pierced by coarse pores which open on internal surface. **Dev.**

BEYRICHIOPSIS Jones and Kirby 1886

(**B. fimbriata*). Shell elongate subquadrate, thickest anteriorly, with median sulcus and small, rounded postmedian lobe; a wide, radiated, marginal fringe present. **Dev.–Penn.**

B. thori Coryell and Johnson (**288**—10–13). **Chester:** Ill. (Clore).

ACRATIA Delo 1930

(**A. typica*). Like *Macrocypris*, but differing in having a more pointed anterior extremity, an abruptly upward bent ventral margin, and reversed overlap. **Miss.–Perm.?**

A. tumida Cooper (**288**—14–16). **Chester:** Ill. (Kinkaid).

***A. typica** Delo (**288**—17, 18). **Penn.:** Tex.; **Perm?:** Kan.

BAIRDIOLITES Croneis and Gale 1938

(**B. crescentis*). Like *Bairdia* in outline and overlap, but differing in possessing curved ridges similar to, but narrower than, those of *Seminolites;* two ridges on each valve, one anterocentral, the other postcentral in position. **U. Miss.**

***B. crescentis** C and G (**288**—8, 9). **Chester:** Ill. (Golconda–Kinkaid).

B. fornicatus Cooper (**288**—19, 20). **Chester:** Ill. (Menard).

CRIBROCONCHA Cooper 1941

(**C. costata*). Flattened anterodorsally like *Healdia* but lacking the round perforations similar to those of *Seminolites;* also lacks the anterior rib of *Seminolites*, having instead of a curved posterior rib a straight, spine-terminated rib. **Miss.**

C. fornicata Cooper (**288**—21–23). **Chester:** Ill. (Paint Creek).

CONDRACYPRIS Roth 1929

(**C. binoda*). Valves massive with no overlap except a slight one of left valve over right along ventral margin; surface ornament smooth but with two transverse ridges on each valve. **L. Dev.**

C. simplex Roth (**288**—25–27). **L. Dev.:** Tenn. (Birdsong), Okla. (Haragan).

SULCELLA Coryell and Sample 1932

(**S. sulcata*). Carapace small; cytherelloid in outline and contact of valves; hinge line arched; right valve extending beyond margin of left all around except along anterior; anterior margin bordered by distinct ridge separated from regular convexity of valve by narrow groove; surface smooth except for shallow sulcus that extends from dorsal margin to a pronounced submedian pit. **Miss.–Perm.**

***S. sulcata** C and S (**288**—24). **Penn.:** Neb. (Missouri), Kan. (Kanwaka), Okla., Tex. (E. Mountain).

CAVELLINA Coryell 1928

(**C. pulchella*), Female shell like *Cytnerella*, but with posterior depression on valve interior almost completely separated from rest of valve by vertical ridge; male with smooth interior. **Miss.–Perm.**

C. glandella Whitfield (**288**—28, 29). **Miss.:** Ind. (Salem).

C. parallela Croneis and Gale (**288**—30, 31). **Chester:** Ill. (Renault–Glen Dean).

***C. pulchella** Coryell (= **Cytherella missouriensis** Knight, **Cytherella wewokana** Warthin, **Cavellina lata** Coryell, and **Cytherella gloria** Coryell and Sample). (**288**—32). **Penn.:** Ind. (Conemaugh), Ia., Mo. (Des Moines), Okla. (Seminole, Holdenville), Tex. (Wayland, E. Mountain).

C. nebrascensis (Geinitz) (**288**—33, 34). Slightly smaller than preceding and less arched dorsally in lateral view. **U. Penn., L. Perm.:** Neb., Kan.

PONDERODICTYA Coryell and Malkin 1936
(= HAMILTONELLA Stewart 1936)

(**Cytherella? bispinulatus* Stewart). Carapace ovate; dorsal margin arcuate, ventral nearly straight; anterior end lower than posterior; valve surface reticulate except near margins; smooth surface widest on ends; left valve larger than right; contact rabbeted, of ridge and groove type; the two posterior spines

PLATE 289

1–6. Cytherelloidea spp. [1: U Tex B 2907 and x42; 2–6: JP 8 and x50]. **1. C. williamsoniana.** Left valve. **2. C. vicksburgensis. 3. C. danvillensis. 4. C. leonensis. 5. C. bastropensis. 6. C. tombigbeensis. 7, 8. Entomis (Richteria) serratostriata** (x15) [CGS, Mus B 29]. End of a specimen; two specimens on a slab. **9–12. Cythere lutea** (female) [JP 5]. Right interior (x33); dorsal view of carapace (x33); shell sculpture (x128); hinge of right valve, viewed dorsally, (x75). **13–15. Cythereis vaughani** (x45) [Fla G S, GB 13]. Right interior; left exterior; left interior. **16–27. Brachycythere** spp. **16–18. B. sphenoidea.** 16, 18: Right and left interiors (x35) [JP 7]; 17: Right valve (x42) [U Tex B 2907]. **19–21. B. ledaforma** [Ark G S, B 2]. Right side, ventral, and dorsal views (x30). **22. B. interrasilis** [JP 8]. Right valve (x40). **23–27. B. russelli** [La G S, GB 7]. Left and right exteriors (x35); interiors of right and left valves and posterior outline (x30). **28–51. Cythereis** spp. **28–30. C. basaleri** [Md G S, Eoc]. Anterior, ventral, and left side views (x20). **31, 32. C. pustulosissima** [U Tex B 2907]. Right side and dorsal views (x42). **33. C. semiplicata** [U Tex B 2907]. Right valve (x42). **34. C. mcguirti** [La G S, GB 7]. Exterior of male left valve (x40). **35–39. C. communis** (x30) [Ark G S, B 2]. Left side; left interior showing hinge; dorsal view; right interior; ventral view of left valve. **40–43. C. (Pterygocythereis) cornuta americana** (x39) [Fla G S, GB 13]. Left and right interiors and exteriors respectively. **44–48. C. exanthemata** (x20) [Md G S, Mioc]. Right valve; two left valves; right valve; right interior. **49–51. C. garretti** (x32) [Fla G S, GB 13]. Right interior; left exterior and interior.

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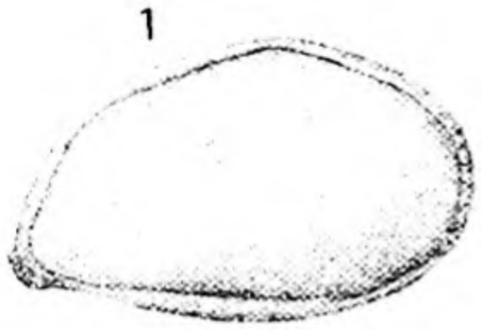

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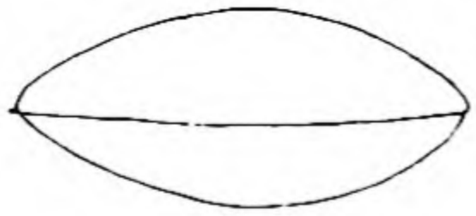

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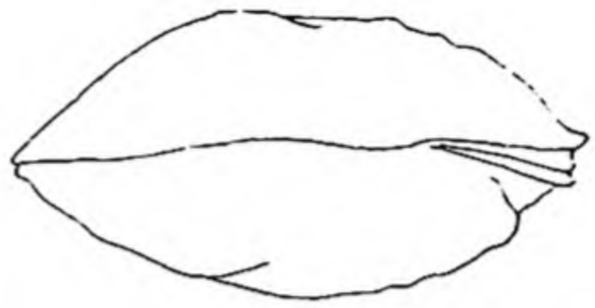

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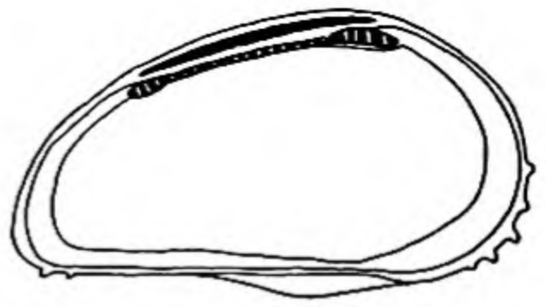

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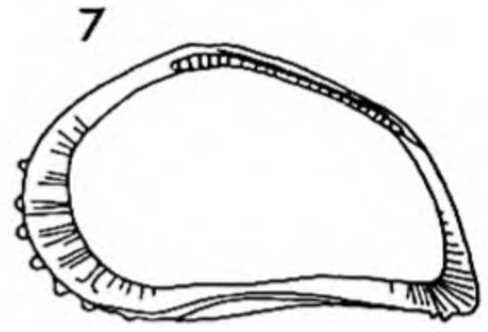

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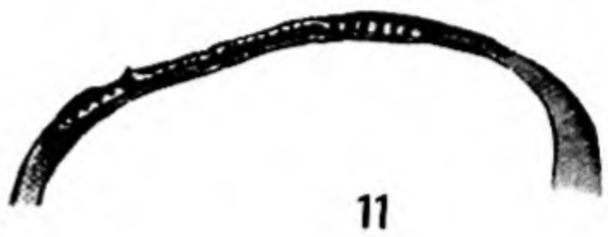

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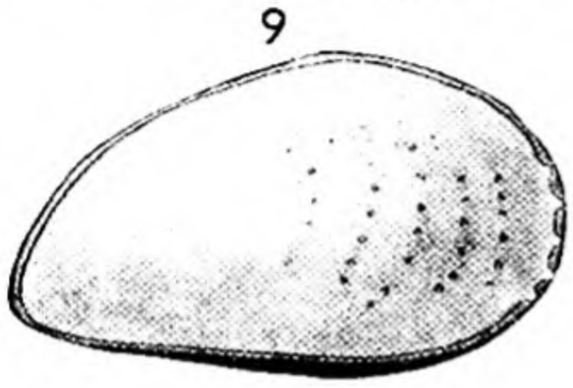

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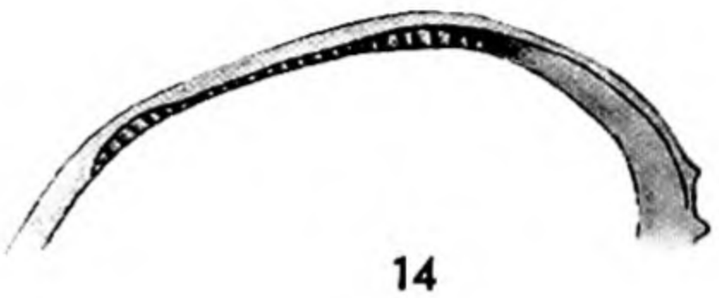

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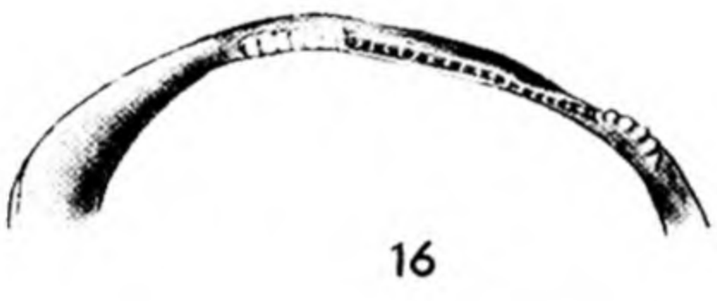

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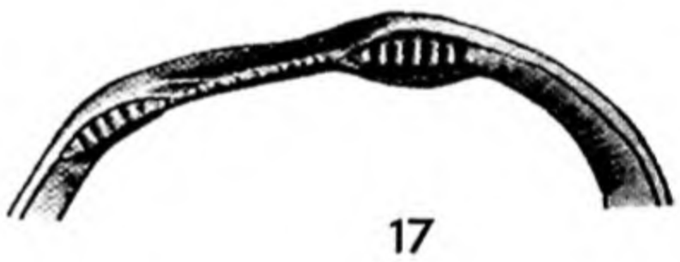

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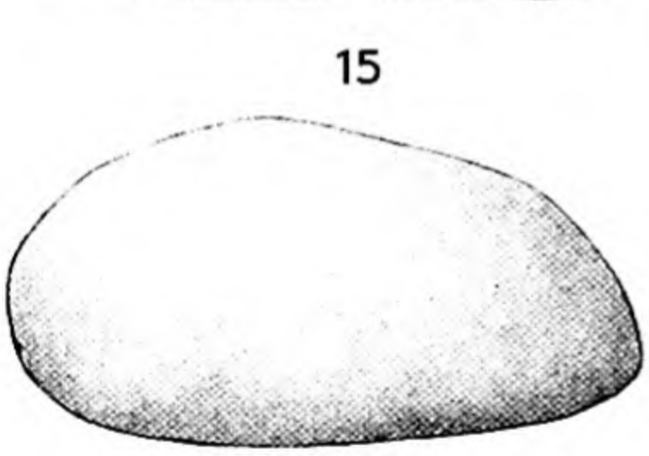

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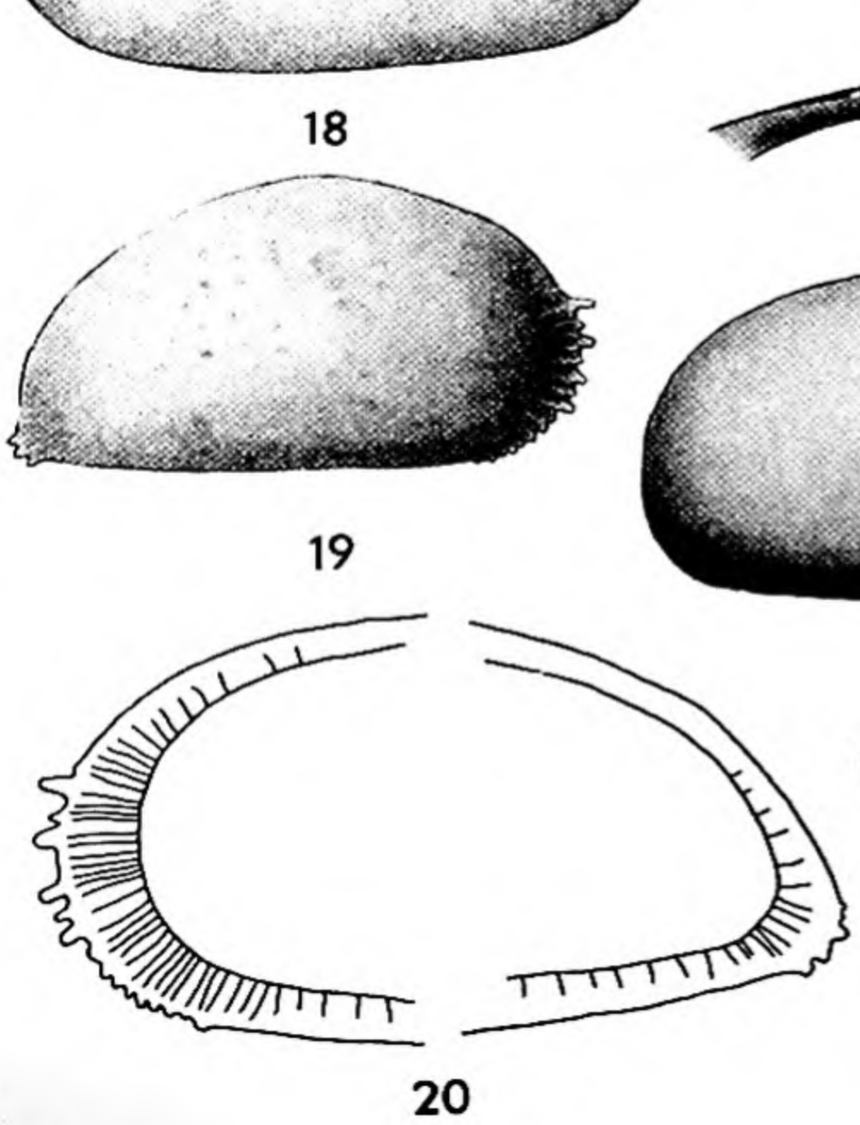

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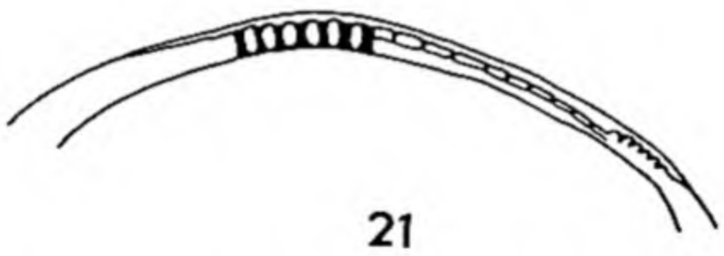

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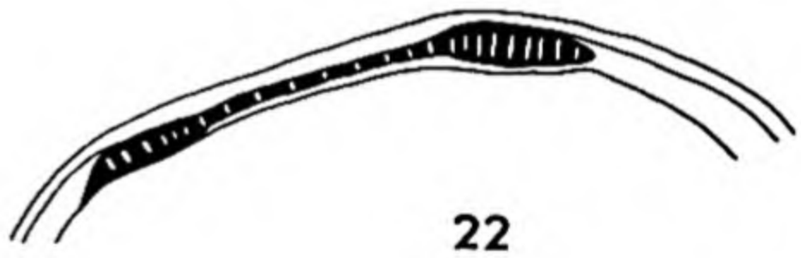

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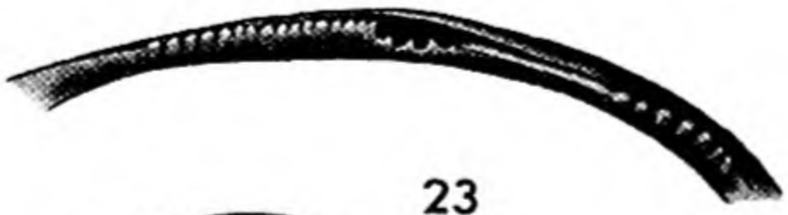

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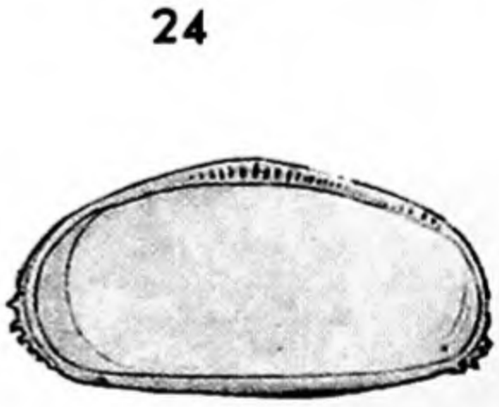

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and an anterior ridge, which usually are present, are diagnostic. **M. Dev.** (Ont.; N. Y., Mich., Ohio).

***P. bispinulata** (Stewart) (288—55–58). **M. Dev.:** Ont. (Widder); N. Y. (Hamilton), Mich. (Traverse), Ohio (Silica), Okla.

CYTHERELLA Jones 1849

(**Cytherina ovata* Roemer). Shell ovate to subquadrate in outline, thick and heavy, surface smooth or slightly punctate; female has posterior depression on valve interior only partly separated, by vertical ridge, from rest of valve; male interior smooth; inner lamella entirely membranous; many species. **Paleozoic?, Mesozoic–Recent.**

***C. ovata** (Roemer) (= **C. navarroensis** (male) and **C. moremani** (female) of Alexander) (288—46, 47). **U. Cret.:** Tex. (Navarro).

C. marlboroensis Ulrich (288—48–51). **Eoc.:** Md. (Aquia).

C. hiwanneensis Howe and Lea (288—42–45). **Olig.** (Vicksburg): Ala., Miss., La.

ARGILLOECIA Sars 1865

(**A. cylindrica*). Carapace small, thin, fragile; anterior end rounded, posterior pointed; dorsal margin convex, ventral fairly straight; right valve larger than left, overlapping both dorsally and ventrally; carapace surface smooth; hingement simple; marginal zone broad; pore-canals long, very numerous, closely spaced especially at anterior end, nearly straight except in anteroventral region, where they curve strongly backward; nearly all canals are simple but a few appear to bifurcate near outer margin of shell. **Cret.–Tert.**

A. faba Alexander (288—39–41). **Paleoc.:** Tex.

PARACYPRIS Sars 1865

(**P. polita*) Carapace elongate, rounded anteriorly, produced posteriorly; left valve slightly larger than right; hinge simple; line of concrescence near and parallel to outer margin; inner margin parallel to, but at considerable distance from, line of concrescence at both ends, coincides with it for a short distance along anterior third of ventral margin. **Cret.–Recent.**

P. weatherfordensis Vanderpool (288—53, 54). **L. Cret.** (Trinity): La., Ark., Tex.

P. perapiculata Alexander (288—52). **Paleoc.:** Tex. (Midway).

CYTHERELLOIDEA Alexander 1929

(**Cytherella williamsoniana* Jones). Like *Cytherella*, but differing in having surface more or less highly ornamented, and with right valve, while larger, not overlapping left around entire periphery. **Cret.–Tert.**

***C. williamsoniana** (Jones) (289—1). **U. Cret.:** Tex. (Navarro.)

The Gulf Coast **Tertiary** may be zoned roughly by the following species, all erected by Howe (1928): **C. tombigbeensis** (289—6), Sabine Eocene; **C. bastropensis** (289—5), Claiborne Eocene; **C. danvillensis** (289—3), Jackson Eocene; **C. vicksburgensis** (289—2), Vicksburg Oligocene; and **C. leonensis** (289—4), Miocene.

BARYCHILINA Ulrich 1891

(**B. punctostriata*). Carapace small, rhomboidal; valves thick, right overlapping left except in posterior half of convex dorsal edge; surface of valves striate, except along edges, where it is smooth; sharply defined narrow or rounded pit. **Sil.–Miss.**

***B. punctostriata** Ulrich (288—35–38). Umbilical pit one-third length of shell from front. **M. Dev.:** Ky. (Jeffersonville).

ENTOMIS Jones 1861

(**E. tuberosa*). Shell subovate with surface smooth in typical species and marked by raised concentric or transverse lines in the subgenus *Richteria*; valves marked by a well developed, slightly curved, submedian furrow extending from ventral edge to center or beyond. **Sil.–Perm.**

E. (Richteria) serratostriata (Sandberger) (289–7, 8). **Dev.:** Canada (Portage–Simpson); N. Y. (Naples); Europe; Siberia.

CYTHERE Mueller 1785

(**C. lutea*). Dimorphs of essentially same shape; shell surface without prominent sculpture, but with shallow pits which are the expanded external openings of pore-canals; canals few, unbranched, nearly straight; hingement shown on pl. 289. **Tert.–Regent.**

Recent investigations (Blake, 1931) show that this genus is actually represented by only a few Recent and fossil species; the many species formerly referred to it belong to other existing or as yet undescribed genera and it has now become common practice to use "*Cythereis*" as a wastebasket for these.

PLATE 290

1–29. Cytheridea spp. **1–4. C. (Haplocytheridea?) monmouthensis** [U Tex B 2907]. Dorsal outline and right side view of female? and male? carapaces (x42). **5–8. C. (Haplocytheridea) sabinensis** [JP 12]. Right side view (x40); dorsal view, left interior, and right interior showing hinge and pore canals (x60). **9–11. C. (Cytheridea) muelleri** (x55) [JP 10]. Right valve; hinge of right and left valves. **12–14. C. (Haplocytheridea) montgomeryensis** (x55) [JP 10]. Right valve; hinge of right and left valves. **15–17. C. (Clithrocytheridea) garretti** (x55) [JP 10]. Right valve; hinge of right and left valves. **18–22. C. (Haplocytheridea) blanpiedi** [JP 10]. 18, 19: Left and right valves (x55). 20: Anterior (left) and posterior marginal areas of right valve showing marginal pore canals (x75). 21, 22: Hinge of right and left valves (x75). **23–25. C. (Anomocytheridea) floridana** [JP 12]. Hinge of right and left valves (x60); right valve (x40). **26–29. C. (Haplocytheridea) subovata** [Md G S, Mioc]. Left and right interiors (x37); left valve and dorsal view (x20). **30–36. Cytherideis** spp. **30. C. mayeri** [La G S, GB 4]. Left valve (x34), the holotype. **31, 32. C. equalis** [USGS, B 128; after Jones, G Mag (3) 10]. Left side and dorsal views (x20). **33–36. C. ashermani** (x20) [Md G S, Mioc]. Large right interior; dorsal view of carapace tilted to show more of the left valve; small left and right valves.

*C. **lutea** Mueller (**289**—9–12). **Recent:** North Atlantic coasts.

BRACHYCYTHERE Alexander 1933

(**Cythere sphenoides* Reuss). Carapace modified oblong in outline; dorsal margin arched; anterior and posterior ends compressed, usually denticulate; left valve much larger than right, which it overlaps strongly along entire dorsal margin and less distinctly along rest of periphery; surface smooth or ornamented; some species bear strong, winglike processes at ventrolateral edge of valves (probably a distinct genus); hinge structure complex; inner margin and line of concrescence coincide throughout, and are at a moderate distance from and parallel to outer margin; radial pore-canals numerous, closely spaced, especially in antero- and posteroventral areas, and widened near outer margin. **Cret.–Olig.** (Vicksburg); **Tert.–Recent** (many species originally referred to *Cythere* probably belong to *Brachycythere*).

***B. sphenoides** (Reuss) (**289**—16–18). **U. Cret.** (Austin, Taylor): Tex.

B. ledaforma (Israelsky) (**289**—19–21). **U. Cret.:** Ark., Tex. (Navarro).

B. interrasilis Alexander (**289**—22). **Paleoc.:** Tex. (Midway).

B. russelli Howe and Lea (**289**—23–27). **Eoc., Olig.** (Claiborne–Vicksburg): Fla., Ala., Miss., La.

CYTHEREIS Jones 1849

(**Cytherina ornatissima* Reuss (not Alexander)). "Form genus"; species vary greatly in form and surface ornamentation; carapace highest at anterior end, with downward slope immediately behind the high, rounded, anterodorsal angle; left valve larger than right, but overlaps conspicuously only at the high, anterodorsal angle; ventral and dorsal margins usually straight, subparallel; anterior end broadly rounded, denticulate along lower half or two-thirds of its length, and usually with thickened and elevated rim; posterior end compressed, triangular in shape, and usually with thickened marginal rim; hinge structure complex, and constant for individual species; over 100 species, many of which probably belong to as yet undescribed genera. (See E. Triebel, *Senckenbergiana* 20, 1938; 22, 1940.) **Cret.–Recent.**

C. pustulosissima Alexander (**289**—31, 32). **L. Cret.** (Washita): Ark., Tex.

C. semiplicata? Reuss (**289**—33). Surface with three short convex ridges extending from middle of valve posteriorly. **U. Cret.:** Tex. (Austin, Taylor).

C. communis Israelsky (**289**—35–39). Surface finely punctate; length 0.75 mm, width 0.38 mm. **U. Cret.** (Navarro): Ark., Tex.

C. bassleri Ulrich (**289**—28–30). **Eoc.:** N. J. (Vincetown), Md. (Aquia); Wilcox and Claiborne of Ala., La., Tex.

C.? mcguirti Howe (**289**—34). **Olig.** (Vicksburg): Gulf Coast.

C. (Pterygocythereis) cornuta americana Ulrich and Bassler (**289**—40–43). **Mioc.** (Chesapeakean): Md., Va., Fla.

C. exanthemata (Ulrich and Bassler) (**289**—44–48). Surface coarsely and rudely spinulose. **Mioc.:** Md., Va., Fla., La.

C.? garretti Howe and McGuirt (**289**—49–51). **Mioc.:** Fla. (Choctawhatchee).

C.? vaughani (Ulrich and Bassler) (**289**—13–15). Surface coarsely reticulated by longitudinal and vertical ridges. **Mioc.:** Md., Va., Fla.

CYTHERETTA Mueller 1894

(**C. rubra*). Closely related to *Cythereis*, but differs as follows — inner margin has a very irregular course, forming in front an S-shaped line, and at ventral margin below the contractor appendages a conical figure, behind which it forms an irregular, flat arch open toward the bottom; carapace elongate, smooth, pitted or ribbed; heavy in adult, lighter in moults. **Eoc.** (Claiborne)–**Recent.**

C. evergreenica (Stadnichenko) (**291**—1). **Eoc.** (Claiborne): Tex.

C. alexanderi Howe and Chambers (**291**—2–6). **Eoc.** (Jackson): Fla., Ala., Miss., La.

C. burnsi (Ulrich and Bassler) (**291**—9–13). **Mioc.:** Va. (Calvert), Fla. (Choctawhatchee), La. (subsurface record).

CYTHERIDEA Bosquet 1850

(**Cythere muelleri* Muenster). This genus, which probably is the most important and widespread (over 100 species) in the Gulf Coast Cretaceous and Tertiary, where it occurs in both marine and brackish sediments, has been divided into a number of subgenera, only three of which are listed here; all American Tertiary species apparently fall in the second and third subgenera.

CYTHERIDEA Bosquet (*ss*). Carapace oblong-ovate; left valve larger than right, overlapping around entire margin; dorsal margin arched, ventral nearly straight, slightly incurved and flanged just anterior to middle, the flange of right valve fitting inside flange in left valve; anterior end obliquely rounded in left valve, and rather evenly rounded in right, bearing about six short spines which are usually more prominent on right valve; posterior end obliquely truncate, with blunt posteroventral angle; entire surface coarsely and rather regularly punctate.

Interior of valves smooth, with inner margin of inner lamella coinciding with line of concrescence except for short distance at anterior end; radial pore-canals fairly numerous; muscle scars somewhat obscured.

Hinge structure in left valve composed of four distinct segments — (1) an elongate, elliptical, anterior socket notched by about six transverse grooves; (2) a high, finely crenulate bar behind the socket; (3) a somewhat lower narrow bar separated from (2) by a diamond-shaped depression; and (4) a

deeply incised posterior socket crossed by five or six transverse grooves.

Hinge structure of right valve also composed of four segments: (1) Anterior dental area consisting of about six teeth; (2) hinge between two terminal dentitions corresponds to the two central segments of the left valve; (3) immediately behind anterior dentition is a finely notched groove, which becomes confluent with the edge of the dorsal margin posteriorly; and (4) the posterior dental area, a narrow line of about five teeth, separated by transverse grooves (See pl **290.**)

HAPLOCYTHERIDEA Stephenson 1936

(**Cytheridea montgomeryensis* Howe and Chambers). Like *Cytheridea ss* in all shell characters except hinge structure (see figures). **Cret.–Recent.**

CLITHROCYTHERIDEA Stephenson 1936

(**Cytheridea? garretti* Howe and Chambers). Identical to *Cytheridea ss* and *Haplocytheridea* in all shell characters except hinge structure (see figures). **Eoc.–Mioc.**

ANOMOCYTHERIDEA Stephenson 1938

(**Cytheridea floridana* Howe and Hough). Close to *Cytheridea* in general shell characteristics, but differing markedly in features of hinge line and muscle-scar pattern (see accompanying illustrations); occurs in both marine and fresh-water sediments. **Tert.**

***C.** (**Cytheridea**) **muelleri** (Muenster) (**290**—9–11). European (introduced for comparison).

C. (**Haplocytheridea?**) **monmouthensis** Berry (**290**—1–4). **U. Cret.:** Md., Tex. (Navarro).

C. (**Haplocytheridea**) **sabinensis** Howe and Garrett. (**290**—5–8). **Eoc.** (Claiborne): Ala., La. (Sabine), Tex.

C. (**Haplocytheridea**) **montgomeryensis** Howe and Chambers (**290**—12–14). **Eoc.** (L. Jackson): Miss.

C. (**Clithrocytheridea**) **garretti** Howe and Chambers (**290**—15–17). **Eoc.** (L. Jackson): Miss.

C. (**Haplocytheridea**) **blanpiedi** Stephenson (**290**—18–22). **Olig.:** Ala., Miss., La.

C. (**Haplocytheridea**) **subovata** Ulrich and Bassler (**290**—26–29). **Mioc.:** Md., Fla., La. (subsurface record).

C. (**Anomocytheridea**) **floridana** (H and H) (**290**—23–25). **Mioc.** (Arca zone): Fla. (Choctawhatchee).

CYTHERIDEIS Jones 1856

(**C. subulata* Brady). Elongate to triangular, with simple hinge; surface smooth, pitted or tuberculated. **Cret.–Recent.**

C. equalis Jones (**290**—31, 32). Bean-shaped valves thinner anteriorly; somewhat wedgelike. **U. Cret.:** Wyo. (Bear River).

C. mayeri (Howe and Garrett) (**290**—30). **Eoc.** (Sabine): Ala., La.

C. ashermani Ulrich and Bassler (**290**—33–36). **Mioc.:** Md., Va., Fla., La.

EUCYTHERE Brady 1866

(**Cythere declivis* Norman). Shell triangular in outline; hinge and ventral margins usually straight, valve surfaces smooth; hinge structure weakly developed; line of concrescence (nature of which is important in differentiating *Eucythere* from *Cytheridea*) at a moderate distance from and parallel to outer margin; inner margin at considerable distance from line of concrescence at anterior end, coincides with line along ventral margin and deviates but slightly from it at posterior end. **Cret.–Recent.**

E. brownstownensis Alexander (**291**—14). **Cret.:** Tex. (Brownstown).

E. brightseatensis (Berry) (**291**—15). **U. Cret.:** Md. (Monmouth). Tex. (Navarro).

E. woodwardensis Howe (**291**—16, 17). **Olig.** (Vicksburg): widely distributed in Gulf States east of Mississippi River.

E. chickasawhayensis Howe (**291**—18). **Olig.** (Vicksburg): Ala., Miss., La.; **Mioc.:** La. (L. Chickasawhay).

CYTHERURA Sars 1865

(**Cythere gibba* Mueller). Shell small, elongate, subquadrate; dorsal and ventral margins nearly straight, subparallel; anterior end rounded, posterior with obtuse caudal process; valve surfaces commonly ornamented; inner margin and line of concrescence coincide throughout their course; area of concrescence broad at both ends and in many species actually comprising greater part of shell; line approaches outer margin only along ventral edge and characteristically forms a posteriorly directed loop in posteroventral region; radial pore-canals variable in number but typically fairly numerous, long, slender, simple, with a slight bulbous enlargement near their distal ends; anterior tooth of left valve is just behind anterior tooth of right and posterior tooth of left valve fits just in front of posterior tooth of right; right valve projects over left on dorsal margin and is differently formed there. **Cret.–Recent.**

Coryell and Fields (1937) recently erected four new genera to include some of the Gulf Coast Miocene species which formerly would have been referred to *Cytherura*; these are KANGARINA C and F 1937, LUVULA C and F 1937, MACROCYTHERINA C and F 1937 and PELLUCISTOMA C and F 1937.

C. cretacea Alexander (**291**—23, 24). **U. Cret.:** Tex. (Taylor, Navarro).

C. byramensis Howe and Law (**291**—19). **Olig.** (Vicksburg): Miss.

C. wardensis Howe and Brown (**291**—20–22). **Mioc.:** Fla. (Choctawhatchee), La. and Tex. (subsurface records).

EUCYTHERURA Mueller 1894

(**Cythere complexa* Brady). Carapace small, relatively thick and heavy; lateral view quadrate; anterior and posterior teeth in right valve; inner margin and line of concrescence coincide throughout

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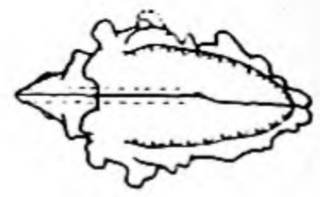

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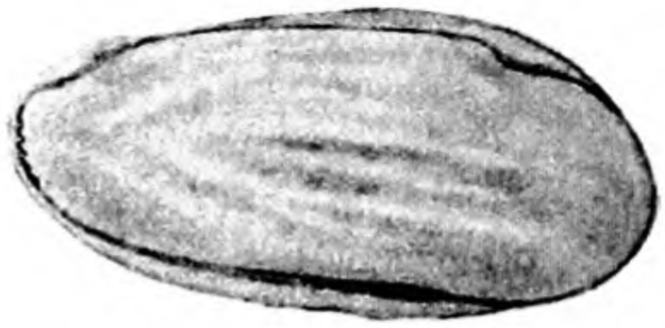

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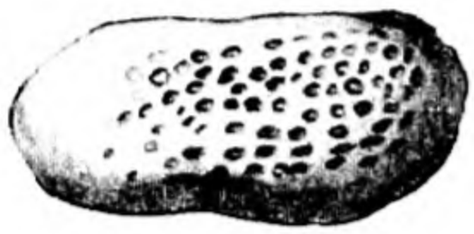

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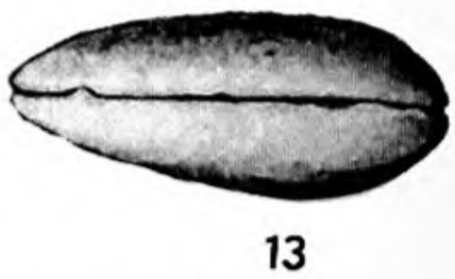

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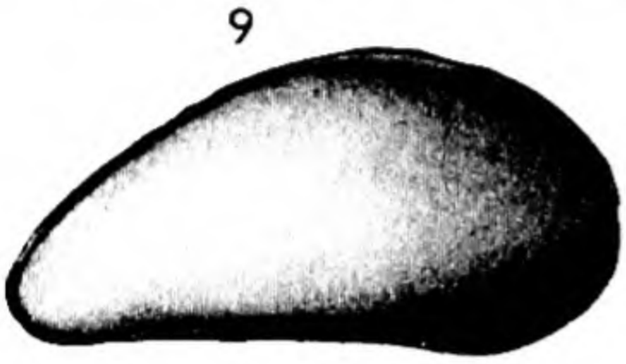

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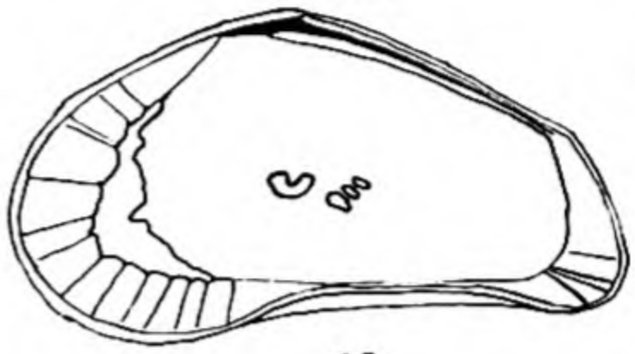

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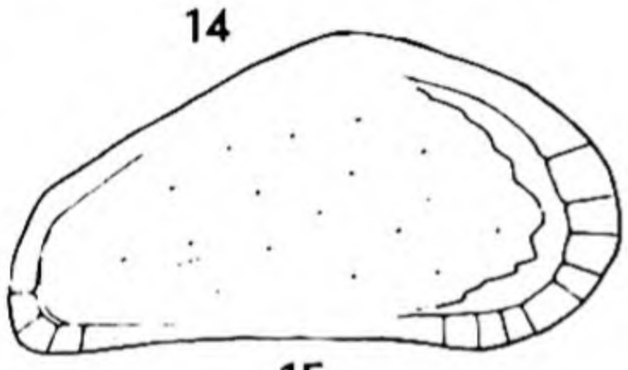

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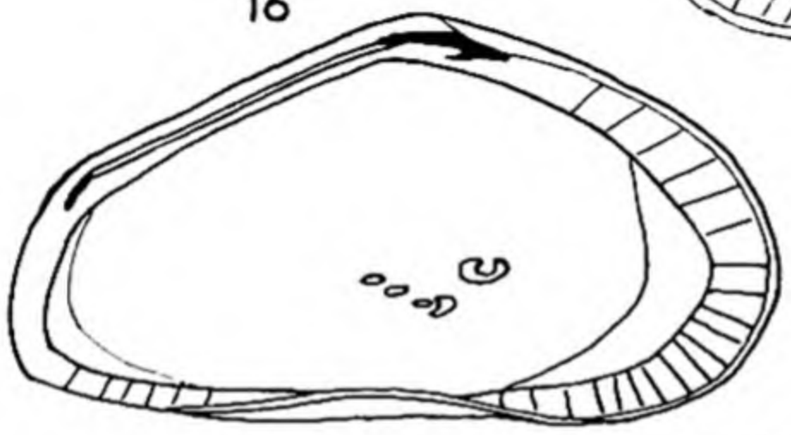

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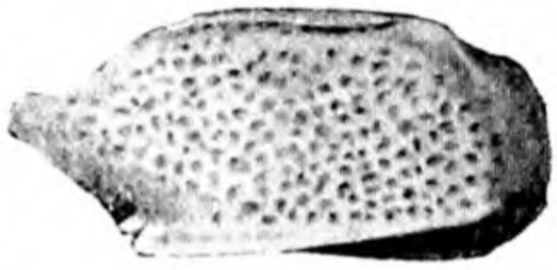

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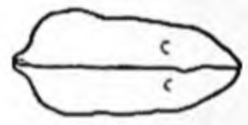

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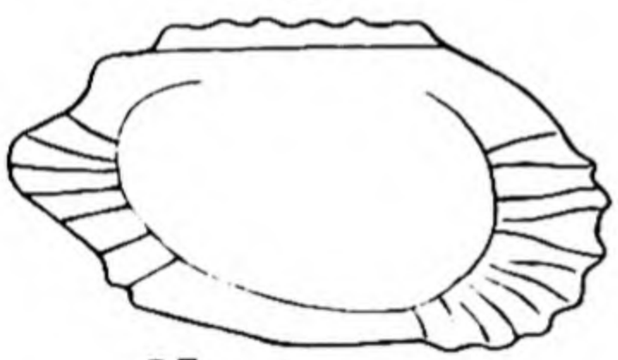

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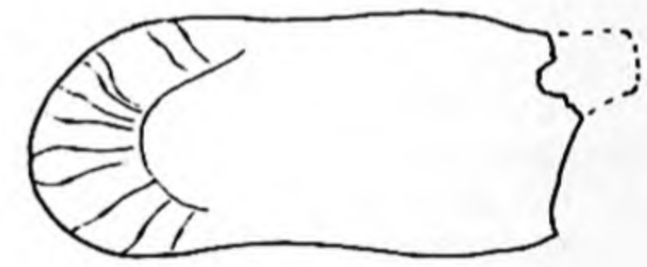

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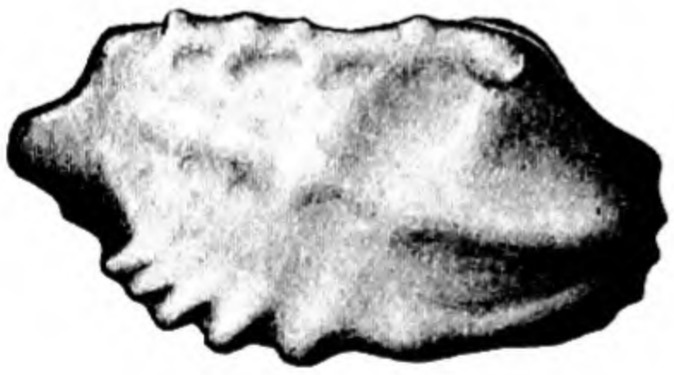

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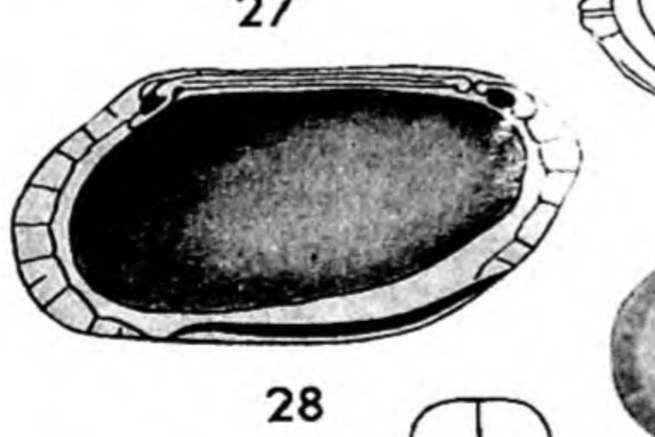

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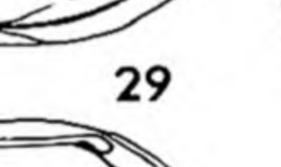

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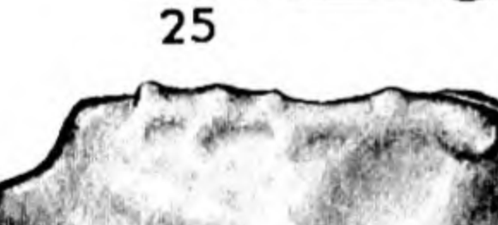

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and run parallel to and at a moderate distance from outer margin of shell; radial pore-canals few, isolated, simple, straight or very slightly irregular in their course. **Cret.–Recent.**

E. chelodon (Marsson) (**291**—25, 26). **U. Cret.:** Ark. (Annona, Ozan), Tex. (Taylor, Brownstown).

E. murdercreekensis Howe and Law (**291**—7, 8). **Olig.** (Vicksburg): Ala. and Miss. (Byram).

LOXOCONCHA Sars 1865

(**Cythere impressa* Baird). Shell rhomboidal to quadrate in outline; dorsal margin straight, ventral straight or somewhat flexuous, curving upward to the short, blunt, compressed caudal process; posteroventral edge of valves keeled; valve surfaces smooth, pitted, or reticulate; anterior cardinal tubercle usually present; hinge teeth usually weakly developed (see Alexander 1934); line of concrescence at moderate distance from outer shell margin, at anterior and posterior ends; radial pore-canals moderately numerous, slender, straight, simple. **Cret.–Recent.**

L. fletcheri Israelsky (**291**—32). **U. Cret.** (Taylor): Ark., Tex.

L. claibornensis Murray (**291**—27, 28). A variable species; differs from *L. woodwardensis* in outline, in more elongate form, and in presence of ridges and rows of pits on ventral side of carapace; differs from **L. perdecora** Alexander, from the Texas Midway, in presence of ribs and pits arranged in rows on ventral part of carapace. **Eoc.** (Claiborne): Ala.

L. woodwardensis Howe and Law (**291**—29–31). **Olig.** (Vicksburg): Ala., Miss., La.

KRITHE Brady, Crosskey and Robertson 1874

(**Cytherideis bartonensis* Jones). Carapace oblong in side view; surface usually smooth; hingement simple; line of concrescence extends vertically downward from dorsal margin, at about one-fifth of shell length from anterior end; except for loops in anterior end and posteroventral angle it runs at a moderate distance from and parallel to outer margin; inner margin and line coincide except when latter makes its sharp, looplike curves toward outer margin at both ends; pore-canals moderately numerous, slender, with large external openings, often curved and of unequal length; many canals open on shell exterior before reaching outer margin; normal canals few, large, conspicuous; dimorphism marked with male shells longer and more slender and less strongly convex than females. **Cret.–Recent.**

K. perattica Alexander (**291**—36, 37). **Paleoc.:** Tex. (Midway).

K. hiwanneensis Howe and Lea (**291**—33–35). **Olig.** (Vicksburg): Ala. (Byram), Miss.

CYTHEROPTERON Sars 1865

(**Cytheropteron convexum* = *Cythere latissima* Norman). Shell ovate in outline, dorsal margin arched; ventral margin straight or convex; anterior end rounded; posterior produced into spinelike caudal process which curves upward; carapace widest at ventral margin; ventrolateral edges of valves bear winglike lateral expansions; valves subequal in size, the left usually somewhat larger than the right; surface smooth or sculptured; hinge of right valve has two teeth which fit in corresponding sockets on left valve; hinge margin of left valve bears a finely crenulate bar which fits into a furrow between terminal teeth of right valve; line of concrescence parallel to outer margin of shell; inner margin and line of concrescence coincide except at anterior end; radial pore-canals few, straight, simple; muscle scar pattern consists of four small scars, with one or two others in front of these. **L. Cret.–Tert.**

EOCYTHEROPTERON Alexander 1933 (**Cytheropteron bilobatum*). Species are roundly tumid or inflated ventrally, do not bear winglike expansions, have left valve usually larger than right and overlapping conspicuously along dorsal margin; hinge structure more primitive than in *Cytheropteron*. **L. Cret.** (Alexander and Howe think that U. Cretaceous and Tertiary species may constitute a new subgenus.)

***C.** (**Cytheropteron**) **latissimum** (Norman). (**292**—1, 2). (Introduced for comparison).

C. (**Eocytheropteron**) **bilobatum** Alexander (**292**—3–5). **L. Cret.** (Weno): Okla., Tex.

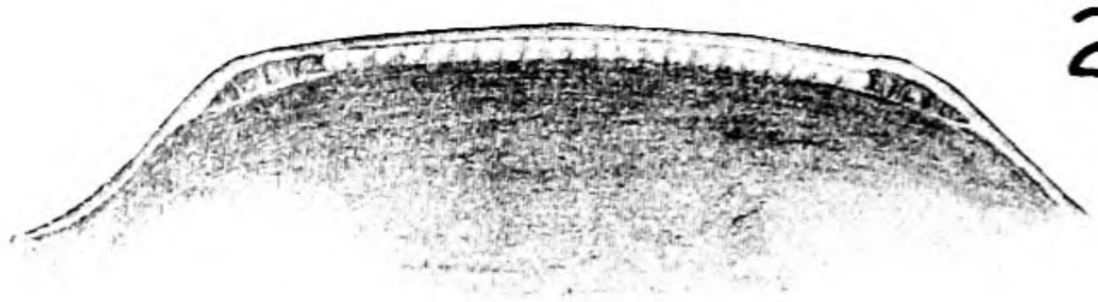
C. (**Eocytheropteron**) **trinitiense** (Vanderpool) (**292**—8–10). **L. Cret.** (Trinity): La., Ark., Okla., Tex.

C. (**Cytheropteron**) **navarroense** Alexander (**292**—6, 7). **U. Cret.:** Ark. (Saratoga), Tex. (Navarro).

C. midwayense Alexander (**292**—14). **Paleoc.:** Tex. (Midway).

PLATE 291

1–6. Cytheretta spp. 1. C. evergreenica [JP 1]. Right valve greatly enlarged. **2–6. C. alexanderi** [La G S, GB 5]. Right hinge (x50); left hinge (x50); left exterior, dorsal, and right exterior views of holotype (x45). **7, 8. Eucytherura murdercreekensis** [La G S, GB 7]. Right exterior and ventral outline of carapace (x100). **9–13. Cytheretta burnsi** (x26) [Fla G S, GB 13]. Exterior and interior of left valve and right valve respectively; dorsal view of carapace. **14–18. Eucythere spp.** [JP 10]. **14. E. brownstownensis.** Right valve (x75). **15. E. brightseatensis.** Right valve by transmitted light showing line of concrescence, inner margin, and pore canals (x75). **16, 17. E. woodwardensis.** Dorsal outline and left interior (x37.5). **18. E. chickasawhayensis.** Right interior (x37.5). **19–24. Cytherura spp. 19. C. byramensis** [La G S, GB 7]. Right exterior (x80). **20–22. C. wardensis** [Fla G S, GB 13]. Left interior and right exterior (x48); dorsal outline (x32). **23, 24. C. cretacea** (x120) [JP 10]. Left valve by transmitted light showing internal features; right exterior. **25, 26. Eucytherura chelodon** [JP 10]. Right valve by transmitted light, showing inner margin and radial pore canals, and right exterior (x100). **27–32. Loxoconcha spp. 27, 28. L. claibornensis** [JP 12]. Left exterior and right interior (x75). **29–31. L. woodwardensis** [La G S, GB 7]. Right and left interiors, and left exterior (x80). **32. L. fletcheri** [JP 10]. Right valve (x100). **33–37. Krithe spp. 33–35. K. hiwanneensis** (x40) [La G S, GB 7]. Dorsal outline; left and right interiors. **36, 37. K. perattica** [JP 8]. Left valve of male (x60); left valve by transmitted light, showing internal features (x80). **38–46. Metacypris spp. 38–42. M. whitei** (x15) [G Mag (3) 3]. End, dorsal, and right side views of male carapace; edge and left side views of female carapace. **43–46. M. pahasapensis** [JP 7]. Left side, ventral, and anterior views (x25).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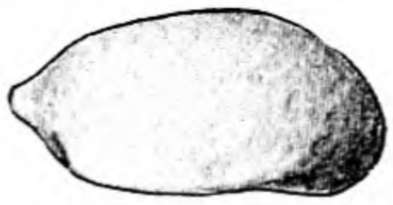
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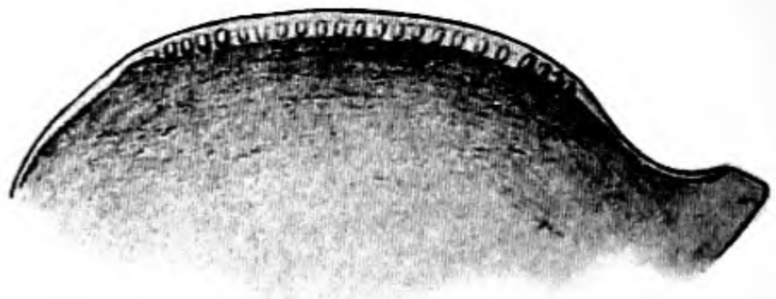
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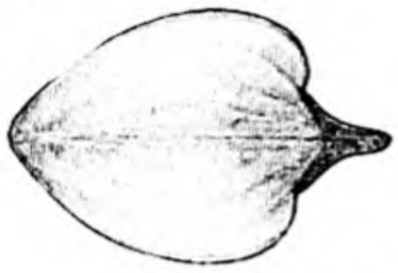
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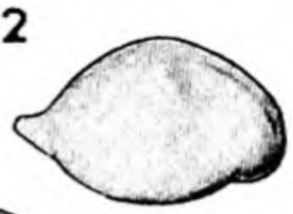
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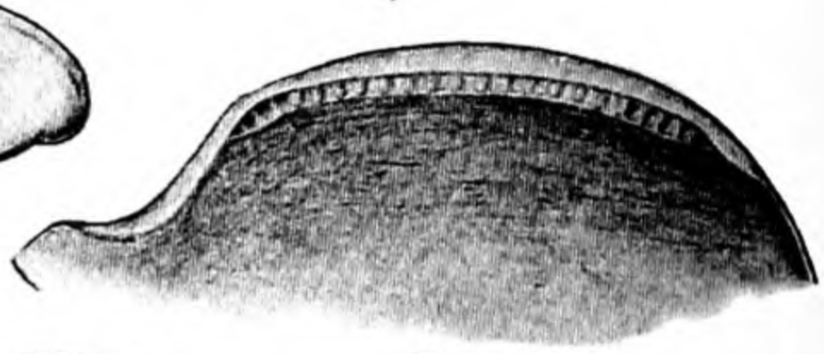
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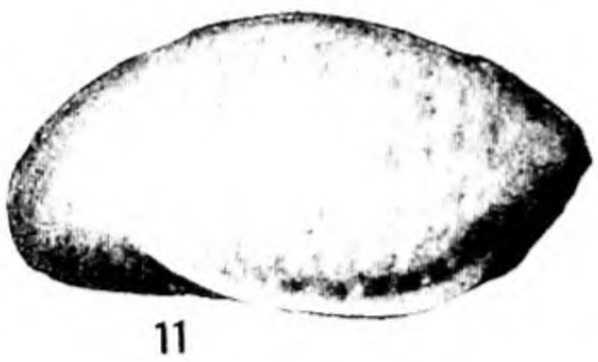
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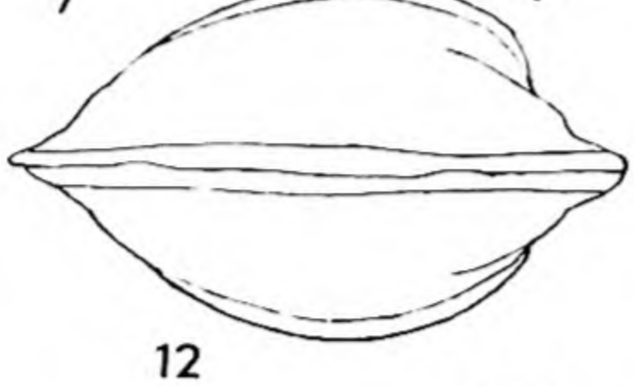
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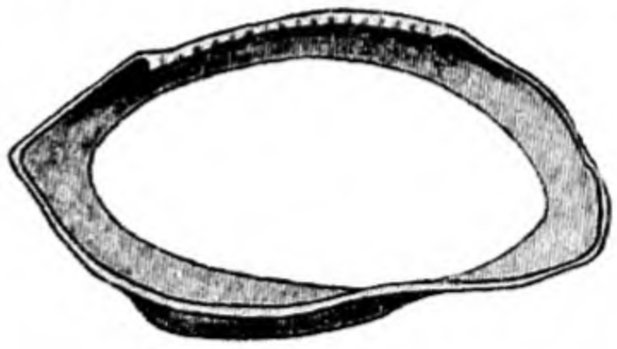
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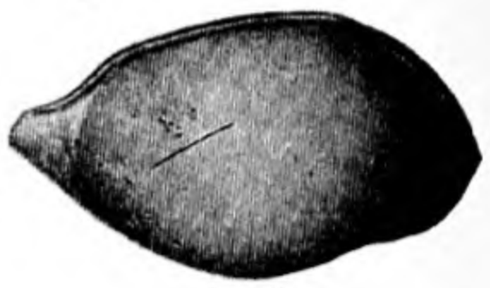
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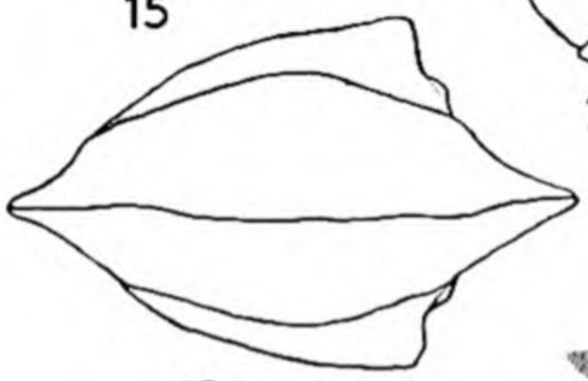
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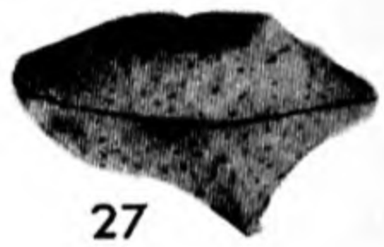
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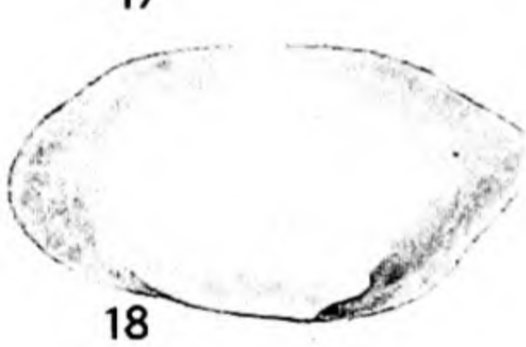
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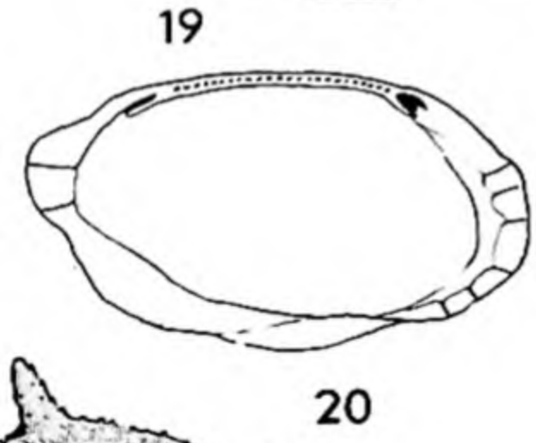
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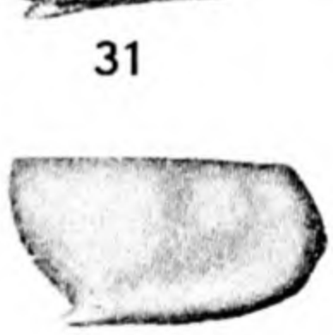
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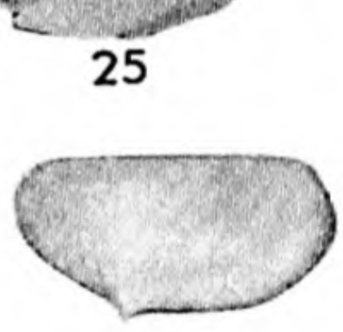
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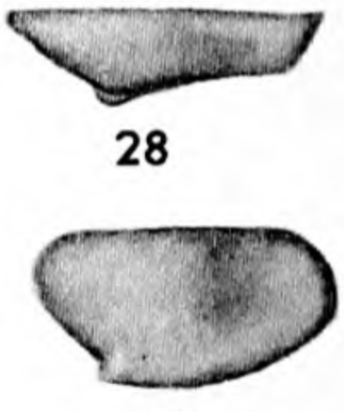
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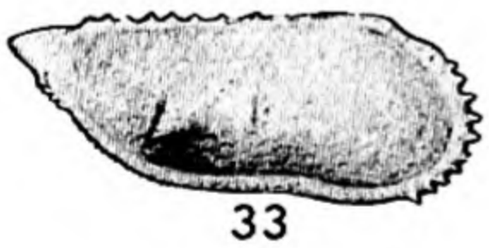
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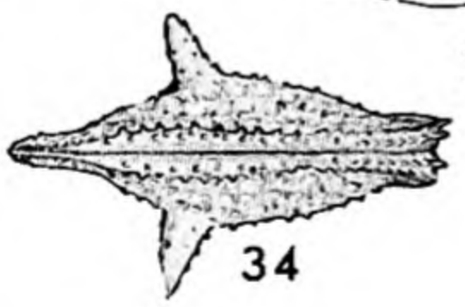
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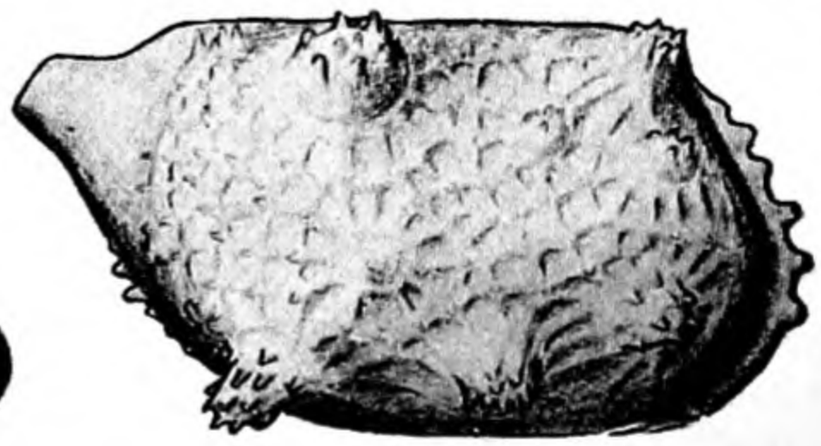
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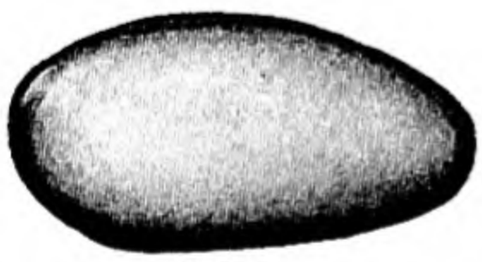
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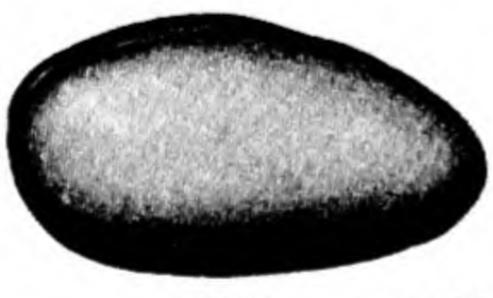
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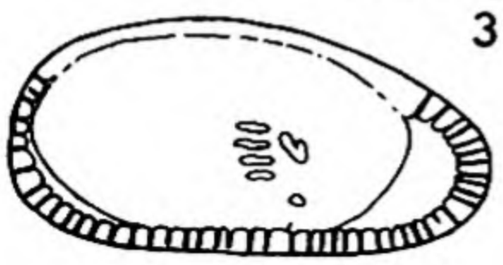
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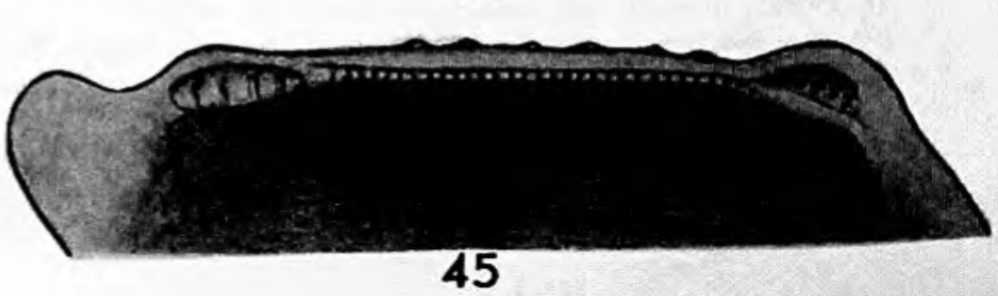
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C. variosum Martin (**292**—11–13). **Eoc.** (Claiborne): Gulf Coast.

C. montgomeryense Howe and Chambers (**292**—16–21). **Eoc.** (L. Jackson): Common throughout Gulf Coast.

C. galericulum Howe and Law (**292**—15). **Olig.:** La. (Vicksburg).

MONOCERATINA Roth 1928

(**M. ventralis*). Straight-backed, with subventral projecting flap or spine, and with weak dorsomedian depression or furrow; left valve grooved to receive hinge of right valve; line of concrescence and inner margin coincide throughout, and their course is near and parallel to the outer margin; radial pore-canals few, simple. **Dev.–Tert.**

M. celsalobata Cooper (**292**—22–25). **Chester:** Ill. (Golconda).

***M. ventralis** Roth (**292**—26–30). **Penn.:** Okla. (Wapanucka, Johns Valley, Dornick Hills).

M. dornickhillica Bradfield (**292**—31, 32) **Penn.:** Okla. (Dornick Hills).

M. pedata (Marsson) (**292**—33, 34). **U. Cret.:** Ark., Tex.

M. rossae Alexander (**292**—41). **Paleoc.:** Tex. (Midway).

ORTHONOTACYTHERE Alexander 1933

(**Cytheridea? hannai* Israelsky). Carapace ovate to quadrate; ventral margin straight, convex, tending to parallel dorsal margin anteriorly, curving upward to caudal process; surface variously ornamented· hinge structure like *Cytheropteron;* line of concrescence and inner margin coincide throughout, and are near and parallel to outer margin; radial pore-canals few, straight, simple; numerous undescribed species in Cretaceous and Tertiary of Gulf Coast. **U. Cret.–Tert.**

***O. hannai** (Israelsky). (**292**—42–45). U. Cret.: Ark. (Ozan), Tex. (Taylor, Navarro).

O. cristata Alexander (**292**—35). **Paleoc.** (Midway): Gulf Coast.

XESTOLEBERIS Sars 1865

(**Cythere aurantia* Baird). Carapace ovate in side view, valves convex, surface usually smooth; hinge-ment shown in pl **292**; line of concrescence very near and parallel to outer margin of shell around entire periphery; inner margin and line coincide except at anterior end; pore-canals numerous, closely spaced, rather large, straight, simple. **Tert.–Recent.**

X. truncata Alexander (**292**—36–40). **Paleoc.:** Tex. (Kincaid, Wills Point).

METACYPRIS Brady and Robertson 1870

(**M. cordata*). Valves very convex, unequally tumid at both extremities; dorsal and ventral margins nearly parallel; ventral margin depressed along posterior half with valves swelling out beyond it; hinge line distinct with thin flanges and narrow furrow; right valve overlapping left; surface pitted in lines; position and arrangement of spines, nodes or tubercles are of specific importance. **Jura.–Cret.**

M. whitei Jones (**291**—38–42). **Jura.:** Colo.

M. pahasapensis (Roth) (**291**—43–46). **Jura.:** S. Dak. (Morrison).

Subclass Cirripedia [1]

The cirripedes or barnacles, being degenerate, differ greatly from typical crustacaens. They are

[1] **Clarke, J. M.,** Cirriped crustacean from the Devonian: *AJS* (3) 24: 55–56, il, 1882; *AJS* (3) 25: 120–125, il, 1883; The structure of certain Paleozoic barnacles: *Am G* 17: 137–143, il, 1896. **Cornwall, I. E.,** Fossil Cirripedia from the Upper Oligocene Sooke formation of Vancouver Island, B. C.: *U Cal Dp G*, B 16: 399–406, il, 1927. **Cushman, J. A.,** Miocene barnacles from Gay Head, Mass., with notes on *Balanus proteus* Conrad: *Am G* 34: 293–296, il, 1904. **Logan, W. N.,** Cirripedes from Cretaceous of Kansas: *Kan U Quart* 6: 187–189, il, 1897. **Matthew, G. F.,** On the occurrence of cirripedes in the Cambrian rocks of North America: *N Y Ac Sc*, Tr 15: 144–146, il, 1896. **Pilsbry, H. A.,** Cirripedia from the Panama Canal Zone: *USNM*, B 103: 185–188, il, 1918; Miocene and Pleistocene Cirripedia from Haiti: *USNM*, Pr 65 (2515): 1–3, il, 1924; Cirripedia (*Balanus*) from the Miocene of New Jersey: *Ac N Sc Phila*, Pr 82: 429–438, il, 1931; An unusual Cretaceous cirriped: *Science* 77: 283–284, 1933. **Ruedemann, R.,** The phylogeny of the acorn barnacles: *Nat Ac Sc*, Pr 4: 382–384, 1918; An ancestral acorn barnacle: *N Y St Mus*, B 251: 93–104, il, 1924. **Van Name, W. G.,** *Protobalanus* and its bearing on the origin and phylogeny of the barnacles: *Am Mus Nov* 197: 1–8, il, 1925; A new specimen of *Protobalanus: Am Mus Nov* 227: 1–6, il, 1925. **Whitfield, R. P.,** A new fossil balanoid from the Marcellus of New York: *AMNH*, B 2: 66–68, 1889. **Withers, T. H.,** Some Paleozoic fossils referred to the Cirripedia: *G Mag* (2) 6: 112-123, il, 1915; A new cirripede from the Niobrara Cretaceous of Kansas: *An Mag N H* 17: 7–11, il, 1926; A new cirripede from the Claiborne Eocene of U. S. A.: *G Mag* (10) 18 (108): 587–588, il 1936.

PLATE 292

1–21. Cytheropteron spp. 1, 2. C. (Cytheropteron) latissimum [JP 7]. Hinge margin of left valve (x105); right valve of female (x35). **3–5. C. (Eocytheropteron) bilobatum** [JP 7]. Right valve (x35); hinge margin of right and left valves (x100). **6, 7. C. (Cytheropteron) navarroense** [JP 7]. Right side and ventral views (x35). **8–10. C. (Eocytheropteron) trinitiense** (x12) [JP 2]. Left interior, right interior and right valve. **11–13. C. variosum** (x100) [JP 13]. Left exterior; dorsal outline; left interior. **14. C. midwayense** [JP 8]. Right valve (x60) **15. C. galericulum** [La G S, GB 7]. Right valve (x60). **16–21. C. montgomeryense** [La G S, GB 5]. Exterior of female and male right valves and a female left valve (x76); dorsal view (x80); left interior (x76); posterior view (x80). **22–34. Monoceratina spp. 22–25. M. celsalobata** (x40) [Ill G S, Rp Inv 77]. Posterior view; right side, dorsal, and ventral views of holotype. **26–30. M. ventralis.** Side and dorsal views (x33) [JP 7]; side and dorsal views of right valve, and another right valve (x27) [B Am Pal 22 (73)]. **31, 32. M. dornickhillica** [B Am Pal 22 (73)]. Side and dorsal views of right valve (x27). **33, 34. M. pedata** [JP 7]. Right side and dorsal views (x35). **35. Orthonotacythere cristata** [JP 8]. Right exterior of holotype (x75). **36–40. Xestoleberis truncata** (x95) [JP 8]. Female and male right valves; right and left interiors; right valve by transmitted light, showing inner margin, line of concrescence, and radial pore canals. **41. Monoceratina rossae** [JP 8]. Right valve (x60). **42–45. Orthonotacythere hannai** [JP 7]. Ventral and left side views (x35); hinge margin of right and left valves (x100).

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sessile benthos, cementing themselves to the substratum by means of a calcareous or membranous base (e.g. *Balanus*) or attaching themselves to the bottom by a fleshy penduncle (e.g. *Lepas*). The substratum may be bedrock, boulders, molluscan shells, other crustaceans, and marine plants. All barnacles are marine, and they thrive in the littoral and neritic zones out to a depth of 2,000 fathoms (12,000 ft). Fossil barnacles, especially isolated plates, may be found in strata as old as the **Cambrian.**

TURRILEPAS Woodward 1865

(=PLUMULITES Barrande 1872)

(**Chiton wrightianus* Koninck = *T. wrightii* Koninck). Body elongate conical with four to six columns of large, triangular overlapping plates, some of which are medially keeled; surface with concentric striae and sometimes radially lined or punctate. **(Camb.?–Dev.).**

T. cancellatus Hall (**293**—5), from **U. Helderberg** of N. Y., **T. devonicus** Clarke (**293**—4), **T. nitidulus** Hall (**293**—6), and **T. tener** Hall (**293**—1–3), from the **Hamilton** of N. Y.

LEPIDOCOLEUS Faber 1886

(**Plumulites jamesi* Hall and Whitfield). Composed of but two ranges of vertical plates of unequal size, interlocking along their basal edges for their entire length. **Ord.–Dev.**

L. sarlei Clarke (**293**—32–35). **M. Sil.** (Niagaran): N. Y. (Rochester).

PROTOBALANUS Whitfield 1888

(**P. hamiltonensis*). Differs from *Balanus* in its greater number of plates (12). **Dev.**

***P. hamiltonensis** Whitfield (**293**—13). Shell small, ovate in general outline, narrowing toward carinal extremity; surface depressed-convex, most elevated at apex of carina; composed of 12 peripheral plates. **Marcellus:** N. Y.

STROBILEPIS Clarke 1888

(**S. spinigera*). Carapace leaf-shaped; composed of four columns of overlapping plates, two of large and unequal size and two others small and unequal. **Dev.**

***S. spinigera** Clarke (**293**—9–12). **Hamilton:** N. Y.

LORICULA Sowerby 1843

(**L. pulchella*). Peduncle squamous; capitulum with two scuta, two terga, four lateralia and a very narrow carina. **Cret.**

L. canadensis Whiteaves (**293**—7, 8). **Cret.:** Man. (Ft. Benton).

BALANUS Costa 1778

(**B. vulgaris*). This is the true "acorn barnacle" with six pieces to the base and a pair of scuta and terga closing the aperture and generally lacking in fossils; the numerous plates of the carapace are illustrated below. **Eoc.–Recent.**

B. concavus Bronn (**293**—14–31). **Mioc.–Recent.** Both Atlantic and Pacific Coasts of N. America, and in Europe.

Other genera: PALAEOCREUSIA Clarke 1888 **(Dev.)**; SQUAMA Logan 1897 and STRAMENTUM Logan 1897 **(Cret.)**; and SCALPELLUM Leach 1817 **(Cret.–Recent).**

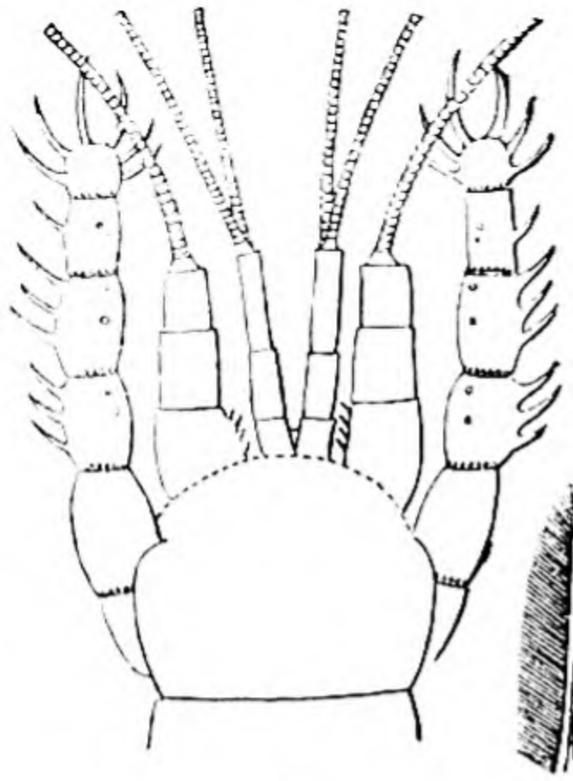
Subclass Malacostraca [1]

This subclass is a diverse group of crustaceans

[1] **Berry, C. T.,** Summary of fossil Stomatopoda: *Am Mid Nat* 21: 461–471, 1939. **Glaessner, M. F.,** Crustacea Decapoda: *Fos Cat*, pars 41: 1–464, 1929. **Ortmann, A. E.,** The geographical distribution of fresh water decapods and its bearing upon ancient geography: *Am Ph Soc*, Pr 41: 267–400, 1902. **Packard, A. S., Jr.,** Syncarida, a group of extinct malacostracus Crustacea: *Nat Ac Sc*, M 3 (2): 123–128, 1886. **Rathbun, M. J.,** South Dakota Cretaceous crabs: *USNM*, Pr 52: 385–391, il, 1917. Decapod crustaceans from the Panama region: *USNM*, B 103: 123–184, il, 1918; West Indian Tertiary decapod crustaceans: *Carnegie Inst Wash*, Pub 291: 157–184, il, 1919; Fossil crabs from the Republic of Haiti: *USNM*, Pr 63 (9): 1–6, il, 1923; The spider crabs of America: *USNM*, B 129: 1–613, il, 1925; The fossil stalk-eyed Crustacea of the Pacific slope of North America: *USNM*, B 138: 1–155, il, 1926; The cancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae, and Xanthidae: *USNM*, B 152: 1–609, il, 1930; Fossil decapod crustaceans from Mexico: *USNM*, Pr 78 (8): 1–10, il, 1930; Fossil Crustacea of the Atlantic and Gulf Coastal Plain: *GSA*, SP 2: 1–160, il, 1935. **Stenzel, H. B.,** Decapod crustaceans from the Middle Eocene of Texas: *JP* 8: 38–56, il, 1934; Middle Eocene and Oligocene decapod crustaceans from Texas, Louisiana, and Mississippi: *Am Mid Nat* 16: 379–400, il, 1935. **Van Straelen, V.,** Crustacea Eumalacostraca (Crustaceis decapodis exclusis): *Fos Cat*, pars 48: 1–98, 1931. **Withers, T. H.,** Cretaceous and Tertiary decapod crustaceans from Jamaica: *An Mag N H* (9) 13: 81–93, 1924; Decapod crustaceans (*Callianassa* and *Ranina*) from the Oligocene of Washington State, U. S. A.: *An Mag N H* 14: 21–127, 1924; Decapod crustaceans from the Oligocene of Anguilla: *An Mag N H* 14: 225–233, 1924; Decapod crustaceans (*Callianassa*) from the Scotland of Barbados: *G Mag* 63: 104–108, 1926.

PLATE 293

1–6. Turrilepas spp. [Pal N Y 7]. **1–3. T. tener.** Single plates (x6). **4. T. devonicus.** A single plate (x6) showing median ridge and plumose appearance of surface. **5. T. cancellatus.** A single plate (x10) showing surface features. **6. T. nitidulus.** A single plate (x6) showing concentric striae and conspicuous perforations. **7, 8. Loricula canadensis** [CGS, Contr Can Pal 1]. Type specimen (x1 and x3). (C, carina; L, lateral plate; T, one of the terga; S, scutum.) **9–12. Strobilepis spinigera.** 9, 10: Approximate restoration, x1, from the side and dorsal view [Pal N Y 7]; 11, 12: Same as preceding but somewhat reduced and with more detail [Am G 17]. **13. Protobalanus hamiltonensis** [Pal N Y 7]. Type specimen (x15), which is broken over posterior portion but shows composition of the capitulum, its 12 discrete plates, and the smooth radial areas. **14–31. Balanus concavus** (x1) [Md G S, Mioc]. 14, 15: Interior and exterior of left tergum. 16–19: Exterior and interior of right and left scuta respectively. 20: Interior of carina. 21, 22: Interior of right and left carinolateral compartments respectively. 23, 24: Lateral view and basis of a large specimen. 25, 26: End and side views of scuta and terga conjoined. 27: Interior of rostrum. 28, 29: Interior of right and left lateral compartments (lateralia) respectively. 30, 31: Exterior and interior of right tergum. **32–35. Lepidocoleus sarlei** (slightly enlarged) [Am G 17]. Right lateral and dorsal, ventral, and left lateral views.



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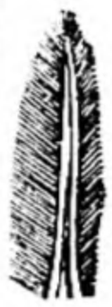

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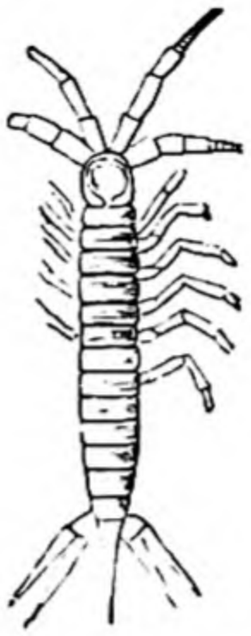

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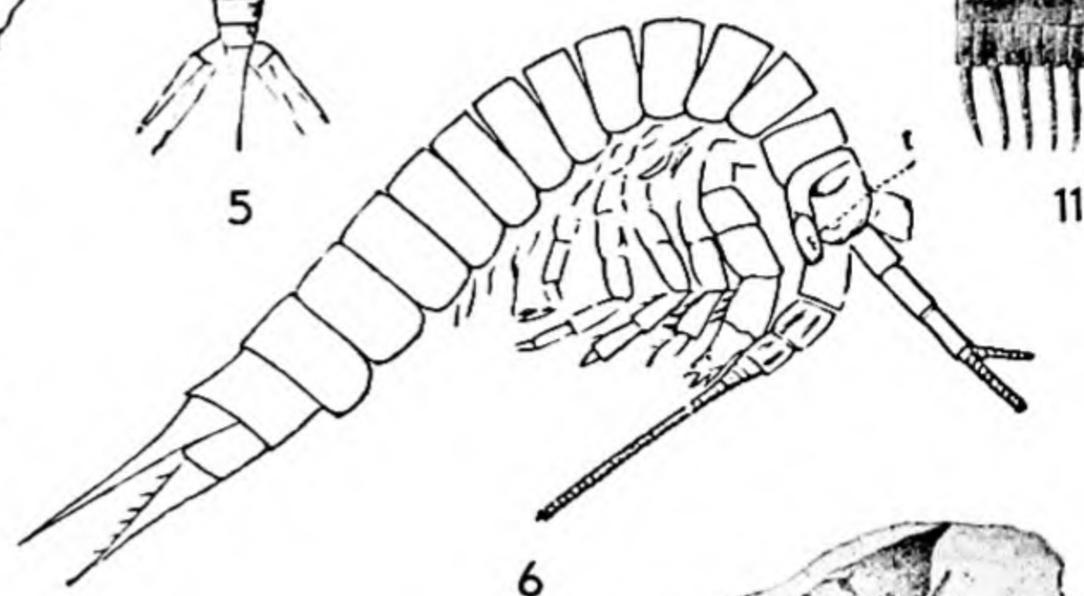

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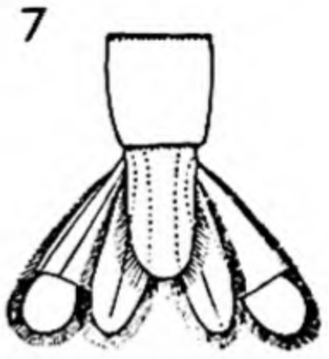

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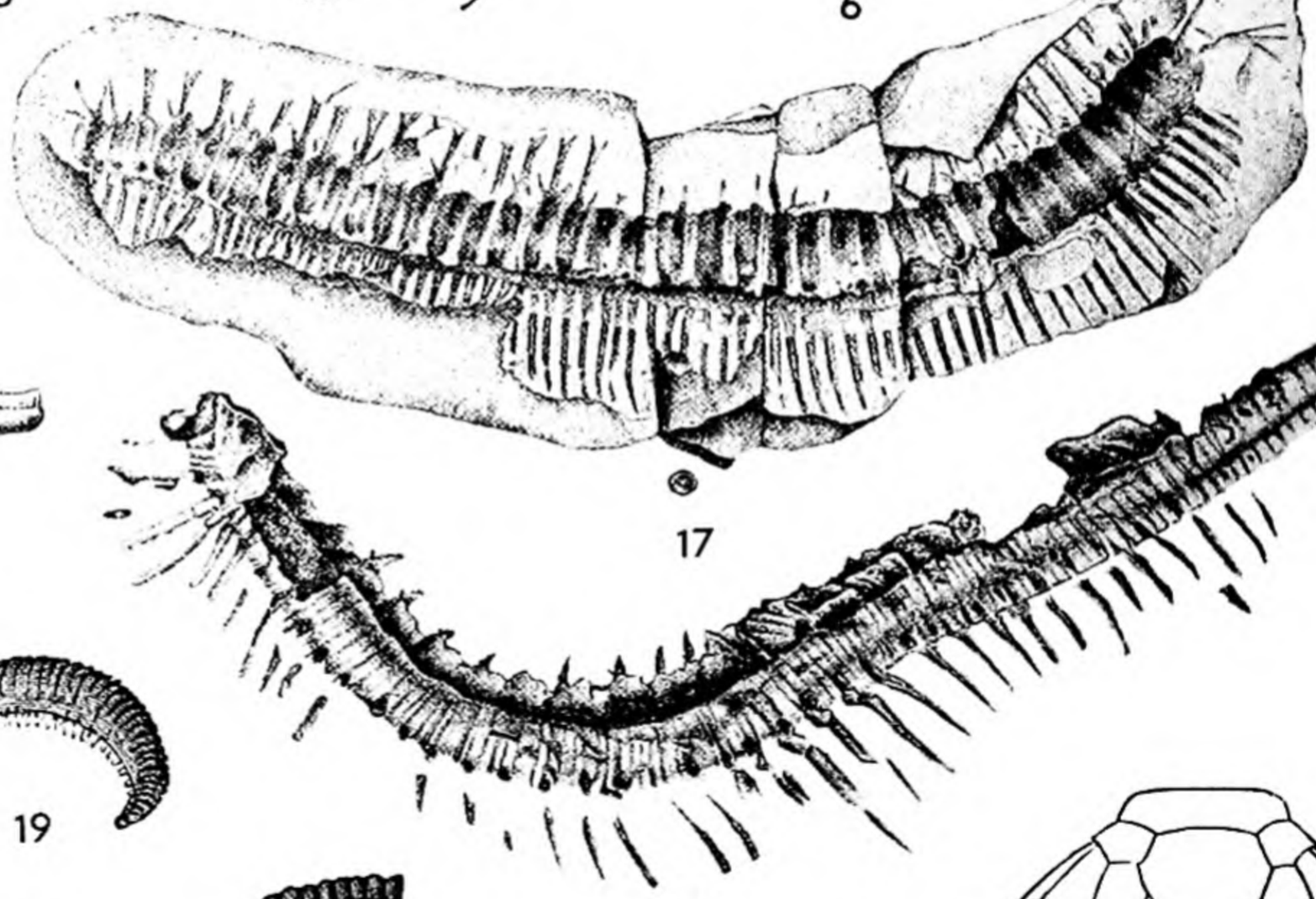

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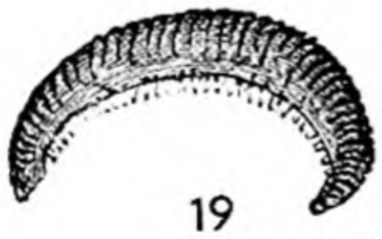

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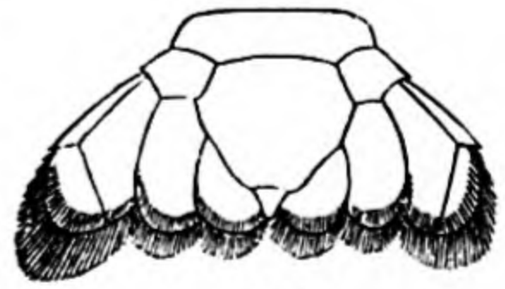

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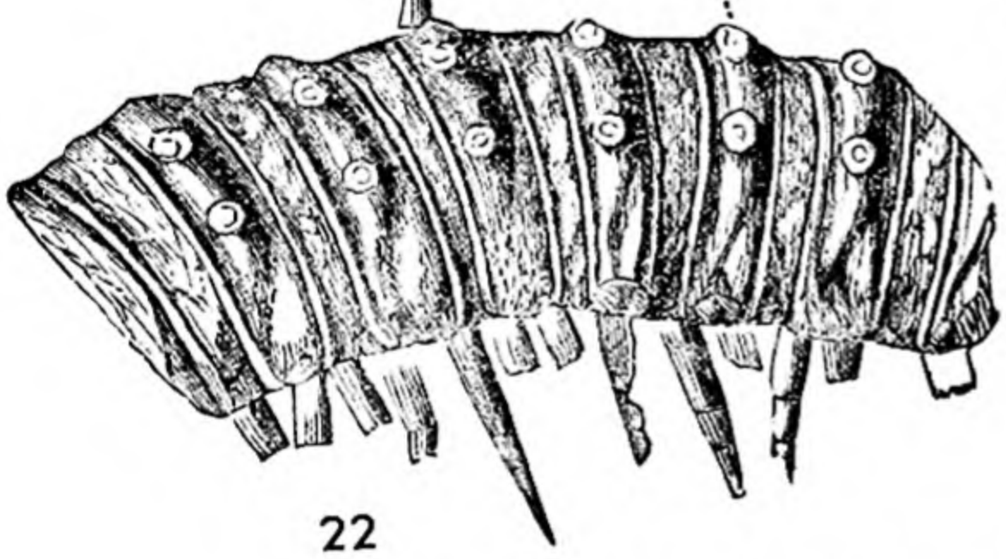

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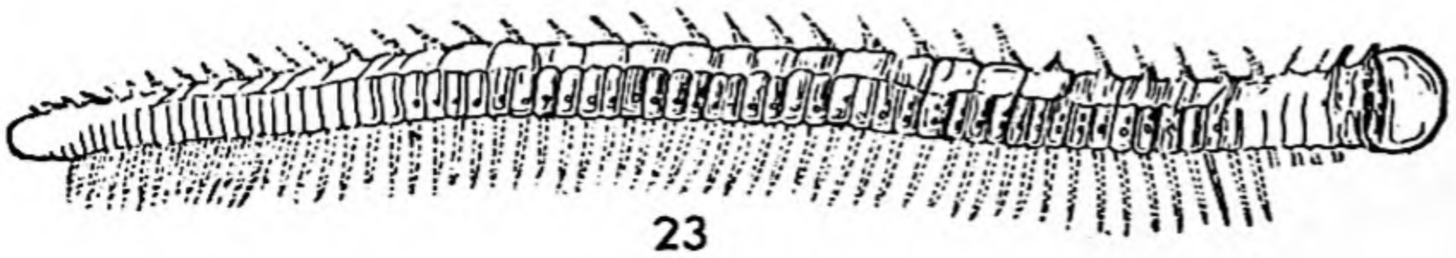

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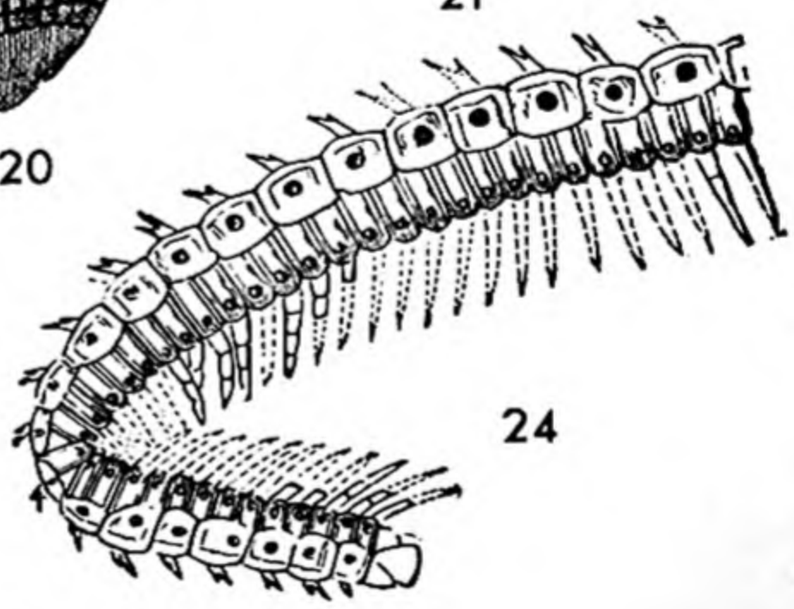

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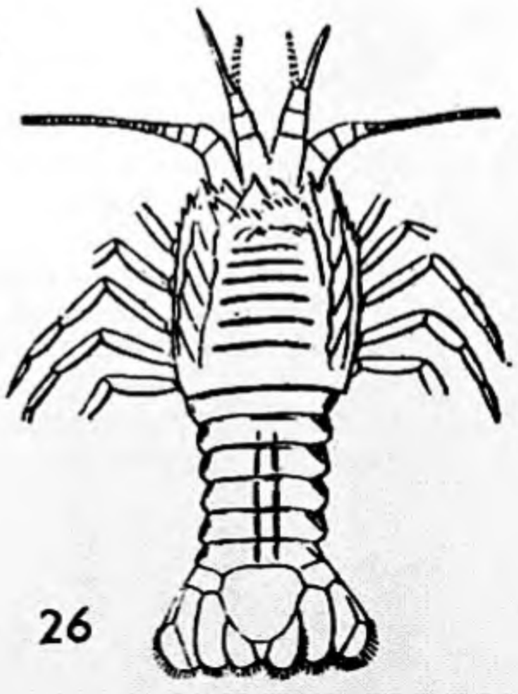

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of which crabs, lobsters, shrimps, prawns (**298**—10), and crayfish are typical living representatives. The fossil record goes back to the Cambrian, but well preserved specimens are uncommon and few genera are of much stratigraphic importance. **Camb.–Recent.**

Division Syncarida. Carapace lacking; first thoracic segment fused with head. **Carb.–Recent.**

PALAEOCARIS Meek and Worthen 1865

(**P. typus*). Shrimplike, with two pairs of antennae of nearly equal length, inner biramous; head as long as first two abdominal segments; thoracic legs long, slender, anterior pair without chelae; telson long and flat. **Penn.**

***P. typus** M and W (**294**—7, 8). **Penn.:** Ill.

Division Peracarida. Small, marine crustaceans with test, if present, consisting of four free thoracic segments and a carapace. **Carb.–Recent.**

PALAEOPALAEMON Whitfield 1880

(**P. newberryi*). Shrimplike crustaceans with a narrow carapace covering the thoracic region, not rostrated in front, but keeled on back and sides; abdomen of six smooth segments terminating in an elongate triangular telson flanked by caudal flaps composed of five elements, of which the outer four are fused into a triangular plate; legs elongate, smooth, almost threadlike except the upper second joint, which is laterally compressed; antennae large and strong. **Dev., Miss.**

***P. newberryi** Whitfield (**294**—12–16). A sharp carina extends along the axis of cephalothorax and bifurcates near anterior extremity; abdomen tapering rapidly to telson. **Dev.:** Ohio (Chagrin); **Miss.:** Ia. (Kinderhook).

ACANTHOTELSON Meek and Worthen 1865

(**A. stimpsoni*). Elongate, slender crustaceans with many-ringed body; rings of thorax and abdomen about equally long; head about length of two thoracic segments; antennae of equal length, inner pair biramous; anterior thoracic legs longer than others; telson long, simple, spinelike, laterally compressed; stylets with second segment longer than first and similar to telson, and all setigerous. **Penn.**

***A. stimpsoni** M and W (**294**—1–6). **Penn.:** Ill.

ANTHRAPALAEMON Salter 1861

(**A. grossarti*). Carapace longer than wide, simple, convex, with sides arched outward; front margin serrate; antennae with wide, square basal joints and slender outer joints, the inner pair of flagellae biramous; abdomen of six segments; telson broad, lateral flaps much subdivided. **Penn.**

A. gracilis Meek and Worthen (**294**—25, 26). **Penn.:** Ill.

Division Eucarida. Carapace covers cephalothorax and eyes are stalked.

Order Decapoda. Decapoda are crustaceans with cephalon and thorax united into a cephalothorax of 13 segments, each segment with a pair of appendages and the whole completely covered with a single carapace, or with one segment free. Anteriorly the carapace is commonly prolonged into a median spine or *rostrum*, which may be continued backward in a median *dorsal ridge* or *keel*. The surface of the carapace is commonly divided by grooves or depressions into regions which correspond in a general way to the grouping of the organs lying below. The central surface of the carapace commonly shows a *sternum*, which occupies the inner field between the thoracic legs, and varies in width according to the distance between the inner leg-bases.

The *abdomen* (*post-abdomen*) is free and distinct and consists of seven joints, of which the terminal one is the *telson*. The first six abdominal segments are commonly supplied with appendages (*pleopoda*).

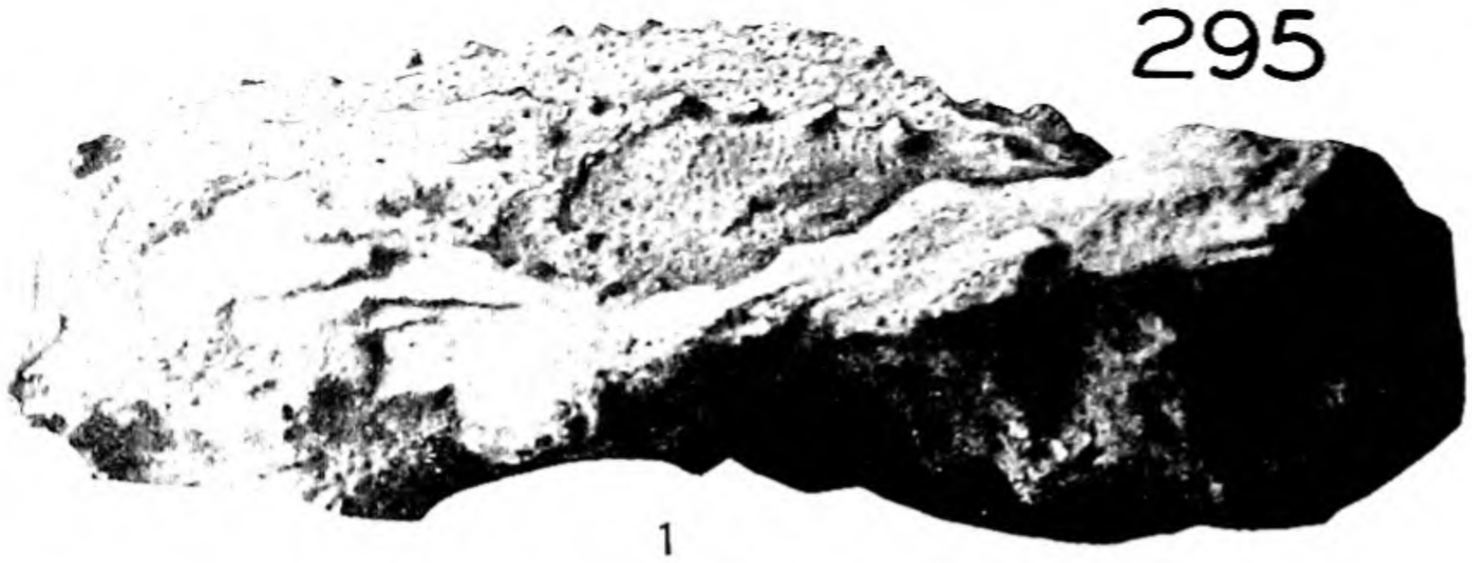
The cephalothoracic appendages are preoral or postoral. The former comprise three pairs; the stalked *eyes* and the two pairs of *antennae* which vary greatly in length and consist of a *shaft* and *flagellum*. The postoral appendages comprise six masticatory and five locomotor pairs. Typically the crustacean limb is biramous, consisting of an inner branch (*endopodite*) and an outer branch (*exopodite*), both many-jointed and arising from a common doubly segmented *protopodite*. Many modifications occur, and one or the other branch may be lacking.

The locomotor appendages or legs proper (*pereiopoda*) are in five pairs, each usually consisting of

PLATE 294

[Figures are x1 unless otherwise indicated.]

1–6. Acanthotelson stimpsoni [1–4: Ind G S 13. 5, 6: Ill G S 3]. 1: Diagrammatic view, enlarged, showing anterior legs and antennae. 2: A stylet enlarged. 3: Dorsal view showing body, stylets, and telson. 4: Side view of laterally crushed specimen. 5: Dorsal view of a small specimen, slightly enlarged. 6: A somewhat distorted and incompletely preserved specimen (x3), flattened sidewise as is usual in the containing concretion. **7, 8. Palaeocaris typus** [Ind G S 13]. Type specimen (x2) and posterior portion (x3), showing telson, caudal lamellae, and last abdominal segment. **9–11. Euphoberia armigera** [Bos Soc N H, M 3]. Anterior portion showing head and antennae (x2.7); succeeding segments of anterior part of body (x1.3), the front being the same as the posterior segment in the preceding figure; segments from stouter part of body (x2), showing spines, legs, and stigmata. **12–16. Palaeopalaemon newberryi.** 12, 13: Lateral and dorsal views of type [Pal N Y 7]. 14–16: Whitfield's drawings (x1.3) [N Y Ac Sc, An 5]. Complete specimen; caudal fin and last thoracic segment, and same from impression in matrix. **17. Acantherpestes major** [Bos Soc N H, M 3]. An almost complete specimen (x0.5) showing branching spines on upper side and legs below; below is shown one of the small disks which cover the surface of the whole fossil, excepting the legs. **18–20. Xyloblus sigillariae** [GSL, QJ 16]. Anterior part of body, enlarged to show lateral pores; complete specimen; posterior part of body, enlarged to show longitudinal ridges. **21. Euphoberia granosa** [Bos Soc N H, M 3]. A nearly complete specimen (x2) showing legs below and spines above. **22. Acantherpestes major** [Ill G S 3]. Portion of a specimen showing segments, spines (*s*), spine bases (*n*), and legs. **23, 24. Euphoberia armigera** [Ill G S 3]. A nearly complete specimen; portion of a larger specimen showing the two kinds of segments. **25, 26. Anthrapalaemon gracilis** [Ind G S 13]. Last abdominal segment and caudal parts of 26 somewhat enlarged; dorsal view of complete specimen, slightly enlarged.



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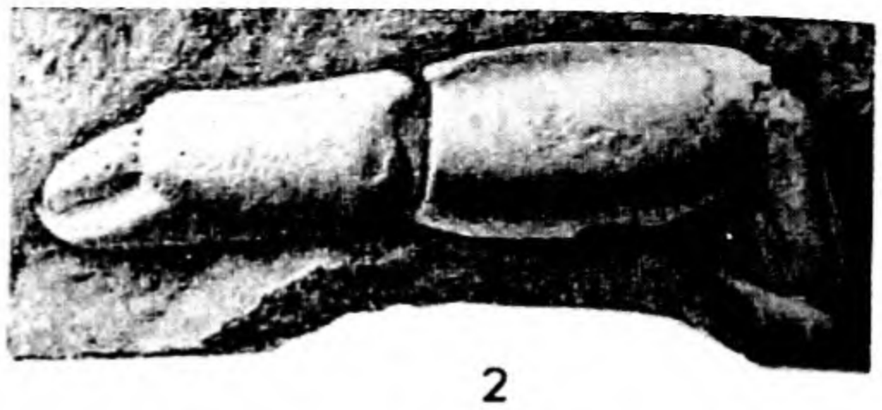

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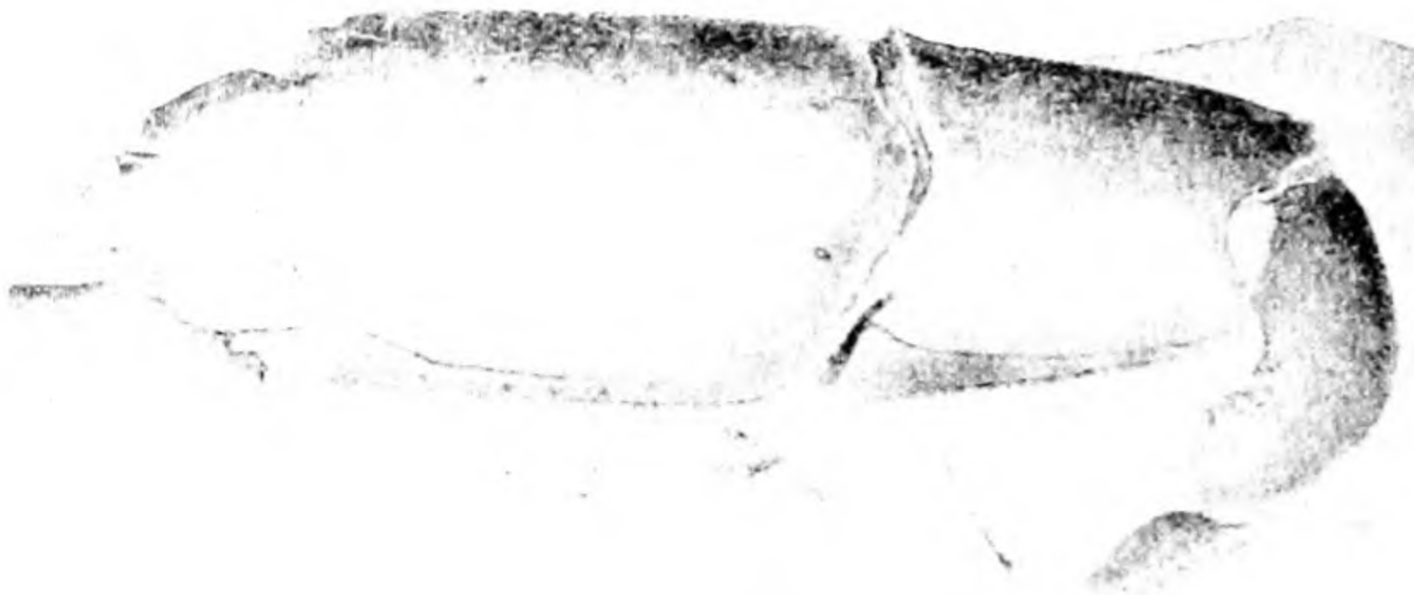

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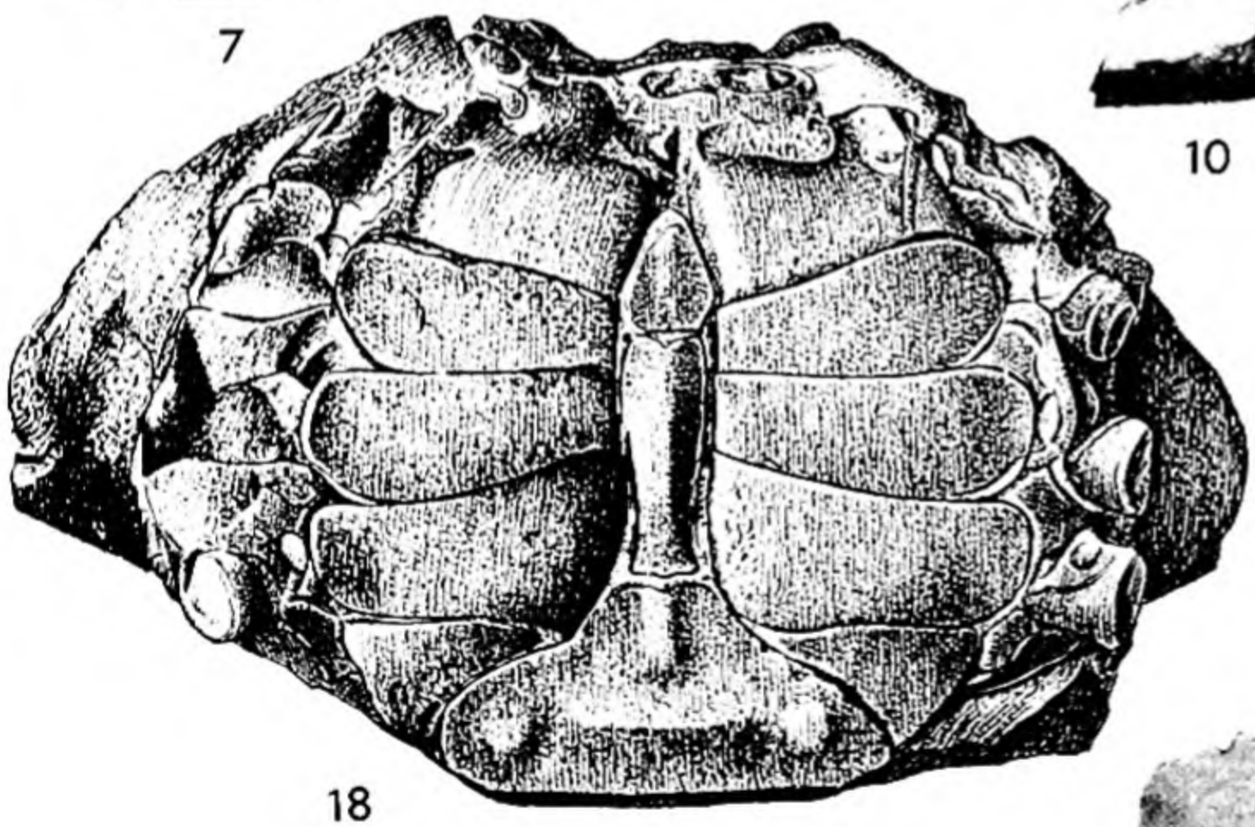

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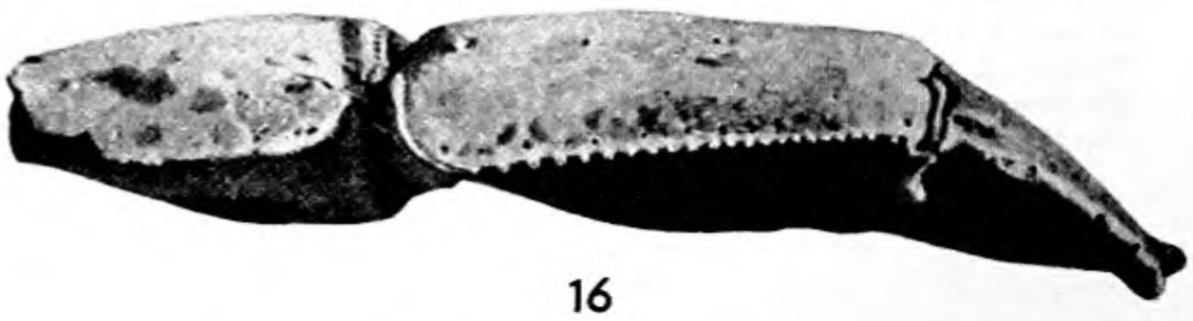

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seven parts. The exopodite is lacking or rudimentary; the leg consists of the protopodite and the five-jointed endopodite. The latter may terminate in pincers or *chelae*, and these are generally best developed on the first pair of thoracic legs (*chelipeds*), which commonly are larger, though often of unequal size in the two legs.

Typical decapods appear first in the Triassic, and though present in Jurassic and Cretaceous strata, do not abound until Tertiary and modern times. American fossil forms are known from the **Cretaceous** and **Tertiary**.

CALLIANASSA Leach 1814

(**Cancer Astacus subterraneus* Montagu). First pair of legs very unequal, with well developed, much compressed chelae; second pair small and chelate; fifth pair subchelate; eye-stalks triangular or oblong and flattened; cornea dorsal, median, small, or absent; rostrum short, triangular, rudimentary or absent. **Jura.–Recent** (widespread throughout Atlantic, Gulf, and Pacific Coasts of N. America).

This important genus, which has wide distribution and great stratigraphic range, has over 90 fossil species and 78 living ones. Since, according to Rathbun (1935, 29–30), "An extensive series of specimens is needed to determine the composition of a species in this genus," only two species are here illustrated to give some idea of the general characteristics of the genus.

C. mortoni Pilsbry (**295**—6–16). Major and minor chelae unlike, the latter much rougher than the former and the fingers longer and more slender. **U. Cret.:** N. J., Del., Md., Ga., Tenn., Ala., Miss., Ark., Tex.

C. oregonensis Dana (**295**—2–5). **Olig.?:** Wash., Ore.

LINUPARUS White 1847

(= PODOCRATUS Geinitz 1850)

(**Palinurus trigonus* Haan). Carapace subcylindrical, fused at sides to epistome, having a median dorsal and two lateral carinae (latter also on abdomen); rostrum small or absent; eyes not inclosed in separate orbits formed by carapace edge; first joint of second antenna fused with epistome; antennal flagella short; none of legs much longer than rest, or, except sometimes the first pair, chelate; tail-fan divided by indistinct sutures into a soft posterior part and a harder front part; telson roughly square behind; no spines on antennular ring; two frontal horns. **Cret.–Recent.**

L. canadensis (Whiteaves) (**295**—1). Prismatic in form; ridges tuberculate. **U. Cret.:** Tenn. (probably Ripley), La. (Eagle Ford), S. Dak. (Benton); Alta (Benton); B. C.

DAKOTICANCER Rathbun 1917

(**D. overana*). Carapace transverse, thick, deeply grooved; front, between eyes, small; orbits well defined, eyes small and tapering; outer maxillipeds broad and flat, but advanced beyond the front; chelipeds elongate, merus large, palm small, fingers probably very long; last leg small, subdorsal. **U. Cret.**

***D. overana** Rathbun (**297**—15). **U. Cret.:** N. J., Tenn. and Miss. ("Selma–Ripley"), S. Dak. (Pierre).

AVITELMESSUS Rathbun 1923

(**A. grapsoideus*). Carapace orbicular-oblong; fronto-orbital distance great, front very narrow; orbits wide, divided into two distinct fossae; maxillipeds elongate, exceeding buccal cavity and as advanced as front; chelipeds massive, of moderate length; fingers elongate; ambulatory legs long and broad; sternum broad. **Cret.**

***A. grapsoideus** Rathbun (**296**—1–4). **U. Cret.:** N. C. (Peedee), Tenn. (Ripley, Selma), Ala. (Ripley), Miss. (Ripley, Selma).

CALLINECTES Stimpson 1860

(**C. sapidus* Rathbun). Large; carapace broad, areolated, anterolateral margin long and armed with nine strong teeth, the last elongated into a spine; front either four or two-toothed; manus with five external costae and not more than two teeth or spines; fingers long, prehensile, teeth stout; legs of last pair adapted for swimming; adbomen of male very narrow, ⊥-shaped. **Eoc.–Recent.**

***C. sapidus** Rathbun (**295**—17–19). Carapace moderately convex, with medium-sized, faintly marked granules scattered over anterior half of carapace, but crowded elsewhere; two frontal or interantennal teeth, triangular acute, and with faint indications of two others on their oblique inner margins; lateral spines in males from three to four times the length of preceding tooth; merus of first pair of pereiopods with three sharp oblique spines on its anterior edge; chelae with 12 to 14 unequal teeth on each finger. **Pleist.:** Sankaty Head, Mass.; N. J.; **Recent:** Cape Cod to Fla.

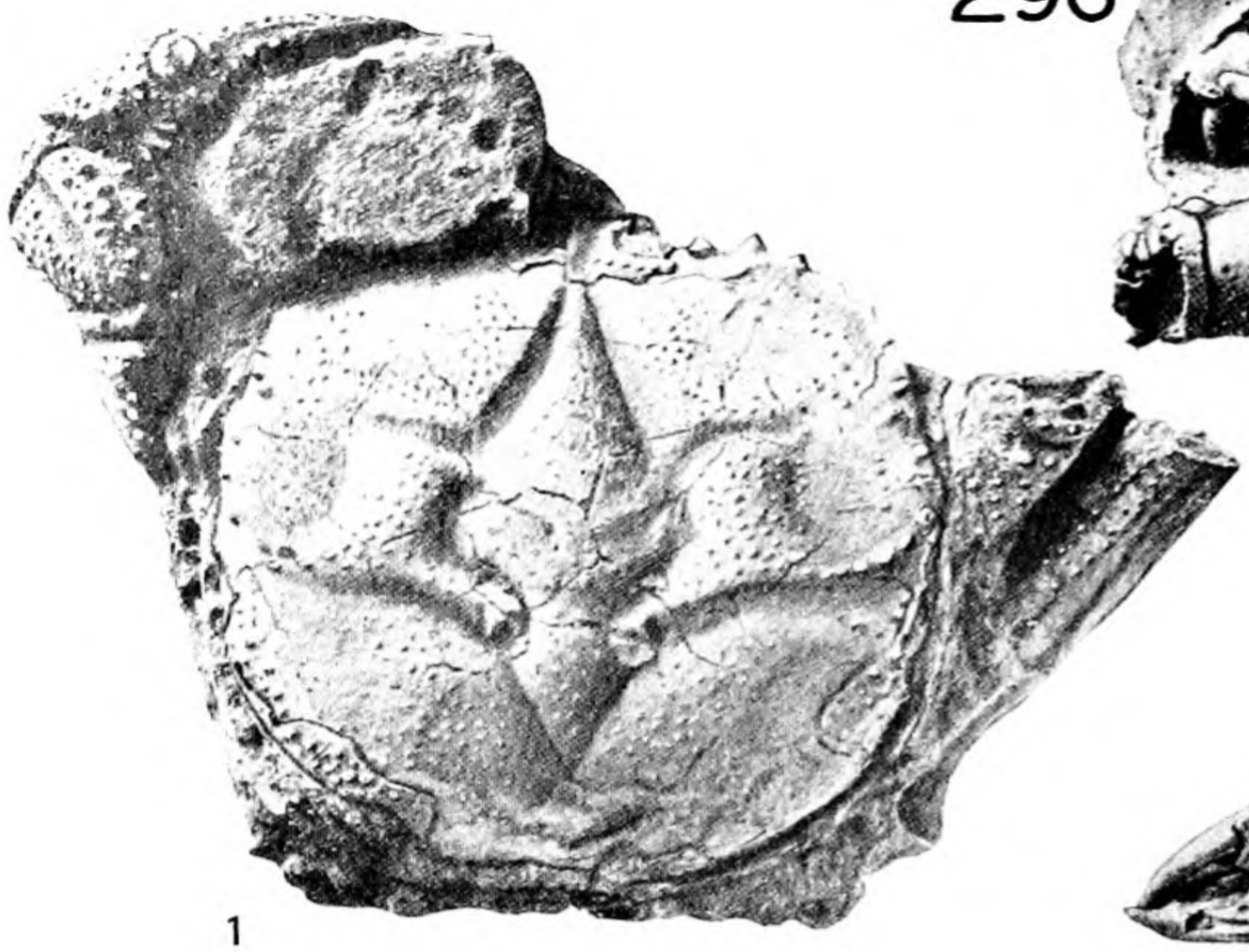
CANCER Linnaeus 1758

(**C. pagurus*). Carapace transverse, subelliptical, often indistinctly areolated; front narrow, cut into five teeth or lobes; orbits small with two fissures in both upper and lower margins; antennal flagellum excluded from orbit; palms longitudinally ridged outside; fingers broad at attachment, tapering to a point; dactyli thick above, upper surface gradually rounding into outer surface, upper edge sometimes cristate. **Eoc.–Recent.**

PLATE 295

[Figures are x1 unless otherwise indicated.]

1: Linuparus canadensis [USGS, PP 137]. Right side of carapace (x2). **2–16. Callianassa spp. 2–5. C. oregonensis** (x1.5) [USNM, B 138]. Left minor cheliped; right chela of male; left chela of female; right wrist. **6–16. C. mortoni** [6, Md G S, U Cret; 7–14, Pal N J 4; 15, 16, USGS, PP 137]. 6: Outside view of cheliped. 7–14: Parts of chelipeds. 15, 16: Upper and inner views of left cheliped (x2). **17–19. Callinectes sapidus** [Md G S, Plioc–Pleist]. Claw (x3); dorsal and ventral views.



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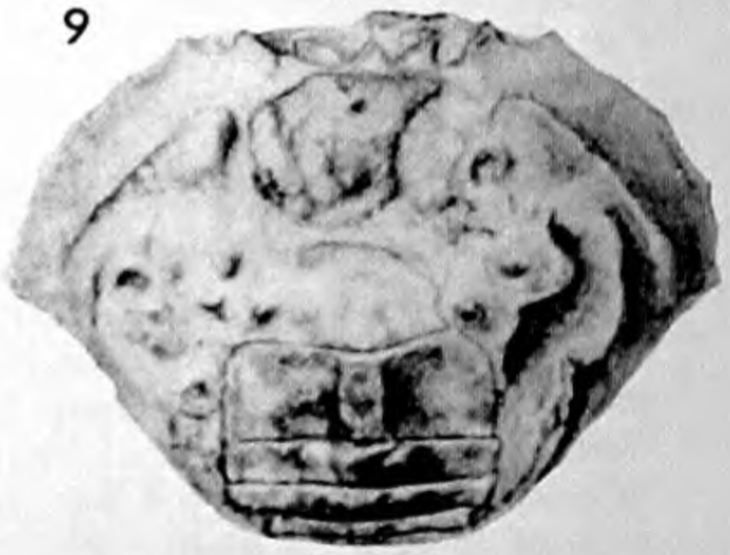

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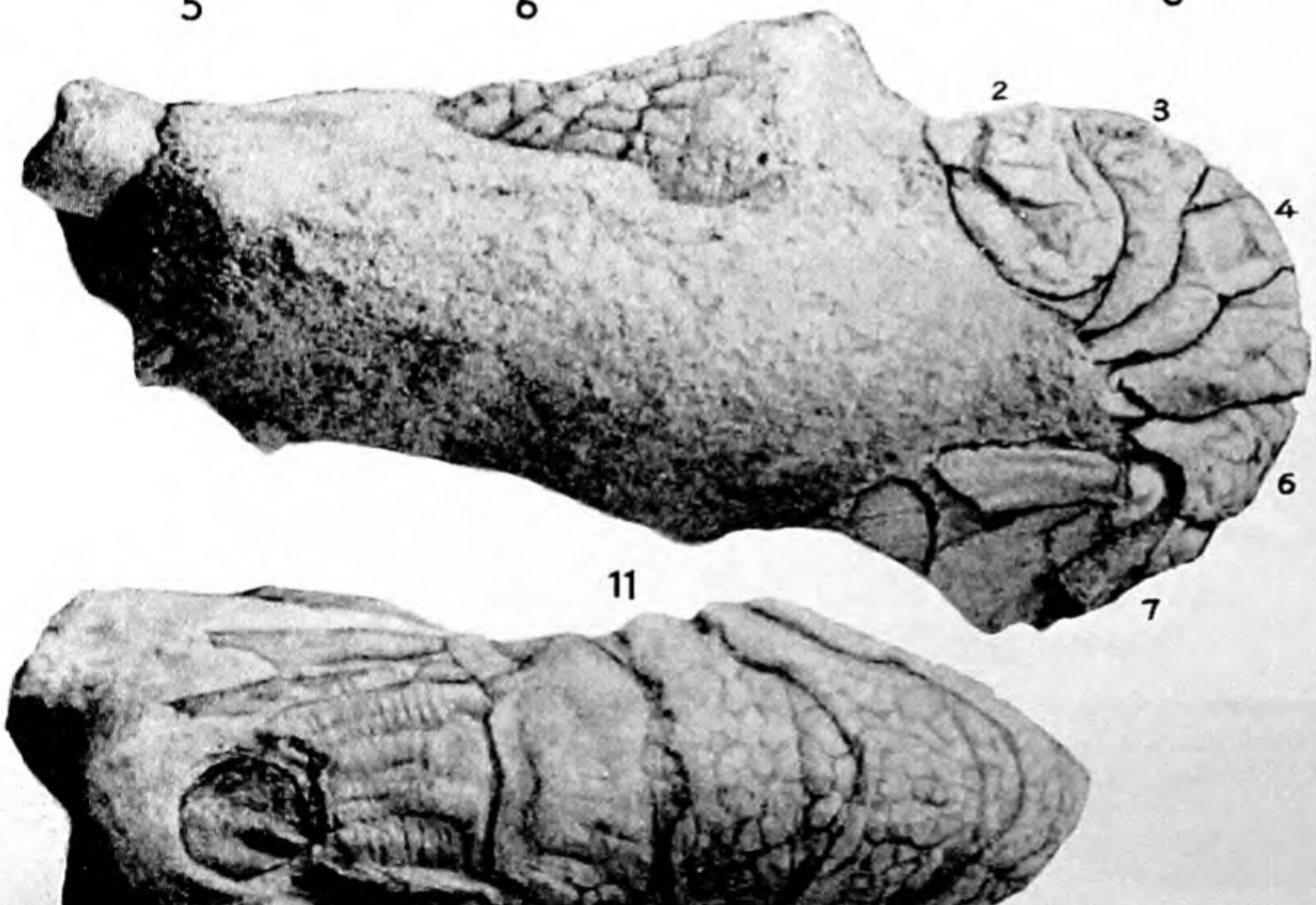

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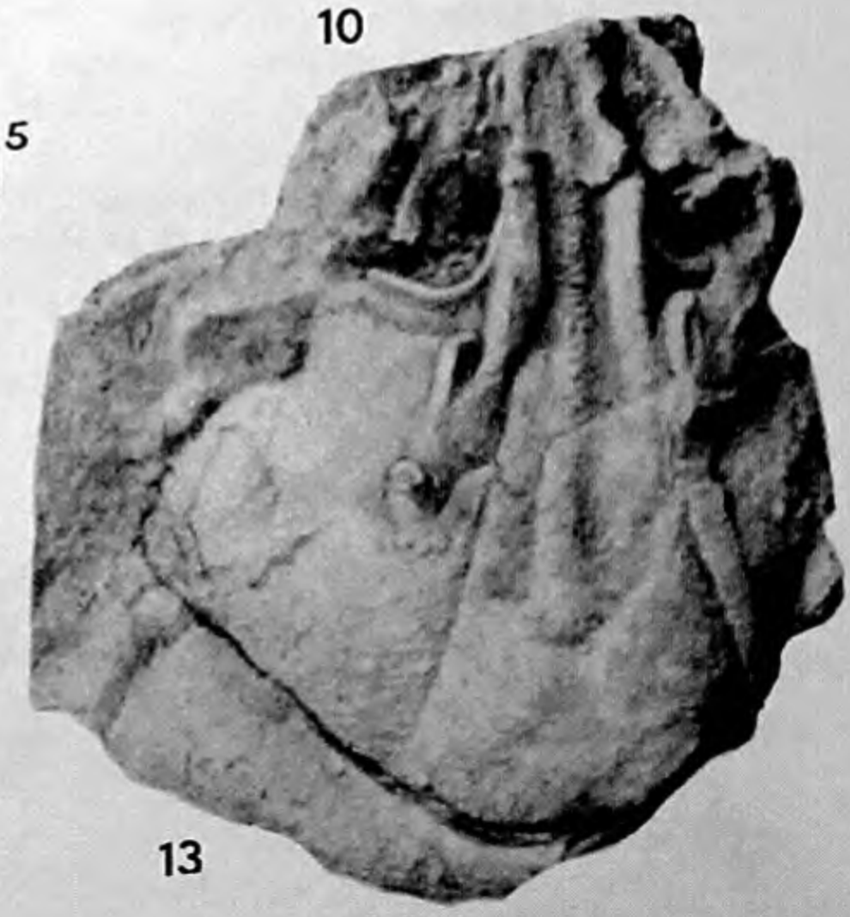

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C. fissus Rathbun (**297**—16). **Plioc.:** Cal. (Etchegoin).

C. attenarius Stimpson (**297**—1). **Recent:** California Coast.

ZANTHOPSIS McCoy 1849

(**Cancer leachii* Desmarest). Carapace very convex, oval, furnished with a definite number of large tubercles or bosses; a few tubercles or lobes on anterolateral margin; front quadrilobate; chelipeds massive, fingers pointed; third, fourth and fifth segments of male abdomen fused. **Cret.–Olig.**

Z. vulgaris Rathbun (**297**—23–25). **Olig.:** B. C.; Wash., Ore.

HARPACTOCARCINUS Milne-Edwards 1862

(**Cancer punctulatus* Desmarest). Like *Cancer*, but the cephalothoracic shield is rounded and its width slightly exceeds its length. **Tert.**

H. americanus Rathbun (**296**—5–10). **Eoc.:** Miss. (Claiborne), La. (Claiborne), Tex.; Mexico.

ASTACUS Fabricius 1775 (part), Milne-Edwards 1837

(**Cancer astacus* Linnaeus). Body robust and ovate; first pair of abdominal appendages of male bifid or toothed at tip; no hooks near base of any of thoracic legs. **Mioc.–Recent.**

A. chenoderma Cope (**296**—11–13). **Mioc., Plioc.?:** Idaho, Ore.

CRUSTACEA INCERTAE SEDIS

STENOTHECA Salter 1866

(**S. cornucopia*). Univalve; shell depressed conical; aperture oval or elliptical; apex eccentric and curved over toward one end of shell; surface with more or less strong undulations and growth lines; reference of this genus to the Crustacea is provisional; it may be a gastropod, pteropod, or heteropod. **Camb.**

S. rugosa (Hall) (**297**—9–14). **Camb.:** Newf.; Labrador; Que.; N. Y.

S. abrupta Shaler and Foerste (**297**—2–4) and **S. curvirostra** Shaler and Foerste (**297**—5). **Camb.:** Newf.?; eastern Mass.

S. levis Walcott (**297**—6). **Camb.:** Newf.; Mass.

CLASS MYRIAPODA

Myriapods (centipedes and millipedes) are air-breathing (tracheate), wormlike arthropods with a distinct head possessing a pair of antennae and three pairs of jaws, and with numerous similar body segments, each of which is furnished with a pair of legs (centipede) or with two pairs (millipede). The earliest known myriapods are from the Devonian Old Red Sandstone of Scotland, and fossil representatives may be expected in strata of that or younger age. A few scattered fossil species have been reported from North America but they are of little importance for this work, and only four will be considered.

ACANTHERPESTES Meek and Worthen 1868

(**A. major*). Spines bifurcate at tip, arranged in dorsal, pleurodorsal, and lateral rows; segments about three times as broad as long. **Penn.**

***A. major** M and W (**294**—17, 22). **Penn.:** Ill.

EUPHOBERIA Meek and Worthen 1868

(**E. armigera*) Head semicircular; body long, slender, slightly tapering, and ending abruptly; segments 75 or more on ventral side and half as many on dorsal; dorsal half of segments rounded, each supporting three or four spines which are curved backward and arranged in rows on back; spines spinuliferous; ventral half of segment bears pair of small, slender-jointed legs. **Penn.**

***E. armigera** M and W (**294**—9–11, 23, 24). **Penn.:** Ill.

E. granosa Scudder (**294**—21). **Penn.:** Ill.

XYLOBIUS Dawson 1860

(**X. sigillariae*). Body elongate and segmented; legs small, numerous; segments 30 or more; anterior segments smooth, posterior with transverse wrinkles giving a furrowed appearance; lateral pores present in some specimens; mandibles two-jointed, last joint ovate and pointed; eves 10 or more on each side. **Penn.** (N. S.; Ill.).

***X. sigillariae** Dawson (**294**—18–20). **Penn.:** N. S.

CLASS INSECTA[1]

PREPARED BY FRANK M. CARPENTER

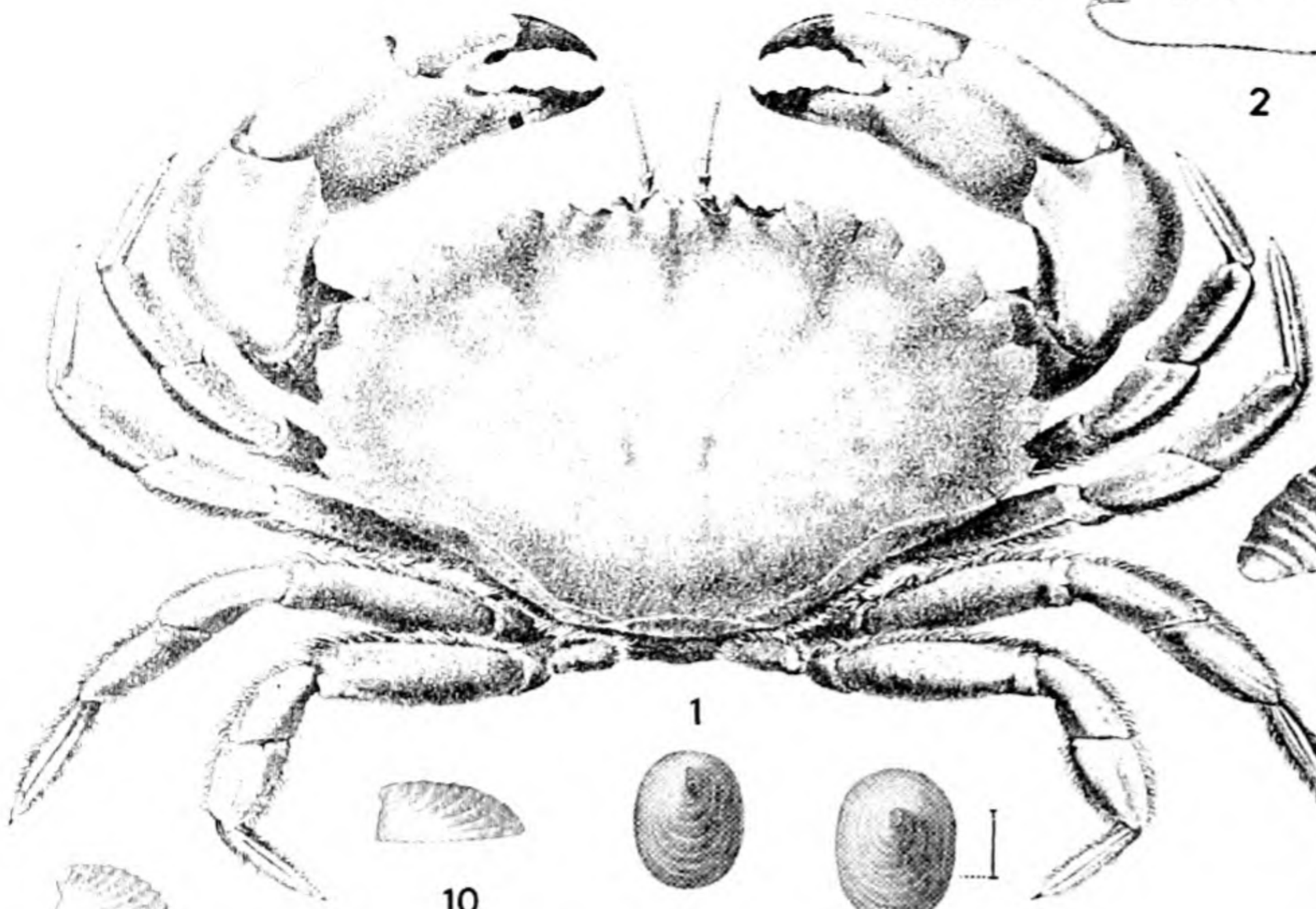
Adult insects are distinguished from other arthropods by the possession of three pairs of legs. Nearly all existing species have wings in the adult stage, also; but since some are apterous, these appendages do not serve as criteria of the class. Tagmosis of the adults is constant throughout the insects. The head,

[1] The following publications contain useful bibliographies of general surveys of faunas: **Carpenter, F. M.,** A review of our present knowledge of the geological history of the insects: *Psyche*, 37: 15–34, 1930; The Lower Permian insects of Kansas, Part 8: *Am Ac Arts Sc*, P 73: 29–70, 1939 (references to other parts included). **Handlirsch, A.,** Revision of American Palaeozoic insects: *USNM*, Pr 29: 661–820, 1906; Palaeontologie, In **Schröder's** Handbuch der Entomologie, 3: 117–306, 1920 (extensive bibliography included). **Handlirsch, A.,** Insecta Palaeozoica: *Fos. Cat*, pars 1 (16): 1–230, 1922. **Tillyard, R. J.,** Kansas Permian insects, Parts 1–20: *AJS* 7–34, 1924–1934. **Scudder, S. H.,** Fossil insects of North America, 2 vols, 1890; Revision of the American fossil cockroaches: *USGS*, B 124: 1–176, 1895. For additional references see papers by C. T. Brues, T. D. A. Cockerell, H. F. Wickham, and others.

PLATE 296

[Figures are x1 unless otherwise indicated.]

1–3. Avitelmessus grapsoideus [USGS, PP 137]. Dorsal view of male, showing carapace and left cheliped; male, showing abdomen and sternum; left chela of male (x2). **4. Avitelmessus grapsoideus** [NCGS 5]. Dorsal view of male holotype (x0.3). **5–10. Harpactocarcinus americanus** (x1.5) [USNM, Pr 73]. 5–8: Chelae, supposedly of holotype. 9, 10: Dorsal and ventral views of holotype, a female. **11–13. Astacus chenoderma** (x1.5) [USNM, B 138]. Portion of carapace and abdomen (2 to 7 segments) in profile, and abdomen viewed dorsally: anterior part of carapace with rostrum, viewed dorsally



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which is nearly always the smallest of the three divisions of the body, possesses a pair of segmented antennae, two compound eyes, usually three ocelli, and the mouth with its associated appendages. The thorax consists of three segments, each of which bears a pair of segmented legs. Two pairs of wings, when present, are attached to the second and third thoracic segments. The abdomen, which typically includes 11 segments, lacks appendages, except for a pair of terminal cerci which occur in some orders (**298**—11).

The immature stages of insects present a bewildering diversity of forms. The young of certain species resemble the adults closely, but those of most exhibit at least a few external differences. In some the differences are in the size of the wings, which reach full development only in the adult; in others the differences are much greater, the immature forms (larvae and pupae) showing none of the adult characteristics.

The Class **Insecta** is usually divided into two subclasses. The subclass **Apterygota,** which consists of four orders, includes those species which are primitively wingless. This group is now nearly extinct, comprising only about 0.3% of the existing species of insects. The subclass **Pterygota,** which is usually regarded as consisting of 41 orders (30 being extant), includes the winged species and those secondarily wingless. Although unquestionable Apterygota have not been found earlier than the Cretaceous, this subclass is generally considered to be ancestral to the Pterygota, of which the first record is in the Upper Carboniferous.

Fossil insects ordinarily occur only in strata which were deposited with unusual rapidity. As a consequence, remains of insects are found abundantly in but a few formations. They are rarely present in marine deposits. Since the softer body structures promptly decompose in water, most fossil insect remains consist only of wings; and apterous and immature specimens are therefore very rarely preserved. Isolated fossil wings or fragments of them, when contained in a black shale, often strongly resemble leaves of plants, but the wing veins are never carbonized, as are those of the leaves. The wings of some insects, (e.g. beetles) are modified to form covers (*elytra*) and have lost their venation.

Insects have comparatively little use as index fossils. The families and even genera usually have long geological ranges, specimens occur abundantly in only a very few deposits, and their partial preservation (i.e. wings alone) necessitates a highly specialized knowledge for their determination. However, the abundant and extensive occurrence of certain conspicuous types of insects within a somewhat limited geologic range might be of significance in certain cases. The cockroaches (Order Blattaria) are in this category. These insects, which as fossils are almost always represented by isolated fore wings, constitute about 60% of the species of insects found in the Upper Carboniferous, and 30% of those in the Permian, but less than 10% of the species in subsequent periods. A high percentage of cockroaches in any deposit is therefore strongly suggestive of the Upper Carboniferous or perhaps the Lower Permian. The wings of these particular insects are sufficiently constant in general structure to be readily recognized (**298**—13). They have sometimes been confused with the leaves of plants, but can be distinguished by the presence of a deep, curved anal suture (**298**—13).

The cases of caddis-fly larvae (Order Trichoptera; Jura. to Recent), which are also easily identified, are common in some Tertiary deposits. Berry (*USNM*, Pr 71, 1927) has mentioned them in the Wilcox group. They are composed of bits of leaves or sand and other debris cemented together and are able to remain in water for a considerable time before they disintegrate.

CLASS ARACHNIDA[1]

Advanced arthropods with body divisible into

[1] **Barbour, E. H.,** Carboniferous eurypterids of Nebraska: *AJS* (4) 38: 507–510, 1914. **Beecher, C. E.,** Restoration of *Stylonurus locoanus: AJS* (4) 10: 145–150, 1900; Eurypterid remains in Cambrian of Missouri: *AJS* (4) 12: 364–366, 1901. **Bell, W. A.,** Merostomata from Coal Measures of Nova Scotia: *R Soc Can*, Pr (3) 16: 159–168, 1922. **Clarke, J. M.,** *Bunaia*, from New York Silurian: *N Y St Mus*, B 219, 220: 128–134, 1920. **Clarke, J. M.,** and **Ruedemann, R.,** The Eurypterida of New York: *N Y St Mus*, M 14: 1–439, il, 1912. **Cockerell, T. D. A.,** A catalogue of the generic names based on American insects and arachnids from the Tertiary rocks, with indications of the type species: *AMNH*, B 26: 77–86, 1909. **Decker, C. E.,** A Permian eurypterid from Oklahoma: *JP* 12: 396, 1938. **Diener, C.,** Eurypterida: *Fos Cat*, pars 25: 1–29, 1924. **Ehlers, G. M.,** A new eurypterid from Devonian of Pennsylvania: *U Mich Mus Pal*, Contr 4 (18): 291–295, il, 1935. **O'Connell, M.,** Distribution and occurrence of the eurypterids: *GSA*, B 24, 499–515, 1913; The habitat of the Eurypterida: *Buffalo Soc N Sc*, B 11: 1–277, il, 1916. **Petrunkevitch, A.,** A monograph of the terrestrial Paleozoic Arachnida of North America: *Conn Ac*, Tr 18: 1–137, il, 1913; Tertiary spiders and opilionids of North America: *Conn Ac*, Tr 25: 211–279, il, 1922; A study of amber spiders: *Conn Ac*, Tr 34: 119–464, il, 1942. **Raasch, G. O.,** Cambrian Merostomata: *GSA*, SP 19: 1–146, il,

PLATE 297

[Figures are x1 unless otherwise indicated.]

1. Cancer attenarius (x0.7) [Bos Soc N H, Pr 6]. A recent male specimen from the California coast; the regions of the cephalothorax are faintly outlined. **2–6. Stenotheca** spp. (considerably enlarged) [NAIF; after Grabau]. **2–4. S. abrupta.** Section of a specimen, the straight side apparently through ventral margin; interior of half of carapace; exterior of carapace. **5. S. curvirostra. 6. S. levis. 7, 8. Eopteria richardsoni** [CGS, Pal Fos 1]. Side and top views. **9–14. Stenotheca rugosa** [USGS, B 10]. Three typical specimens; a somewhat enlarged shell; side and summit views of a very small shell. **15. Dakoticancer overana** [USGS, PP 137]. Ventral view (x3) showing sternum and appendages of first abdominal segment. **16. Cancer fissus** (x2) [USNM, B 138]. Dorsal view of holotype. **17–22. Ribeiria** spp. **17–19. R. (Ribeirina) calcifera** [CGS, Pal Fos 1]. Dorsal, end, and side views. **20–22. R. nuculitiformis** [B Am Pal 3 (13)]. Side and posterior views, and side view of a smaller specimen. **23–25. Zanthopsis vulgaris** [USNM, B 138]. Dorsal view of male holotype; front view of a paratype; ventral view of female carapace.

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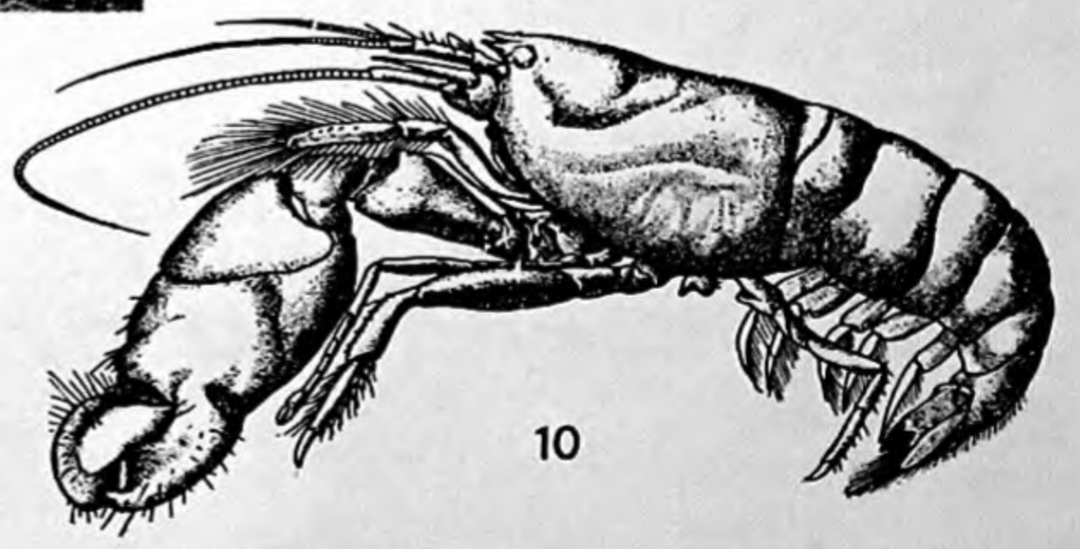

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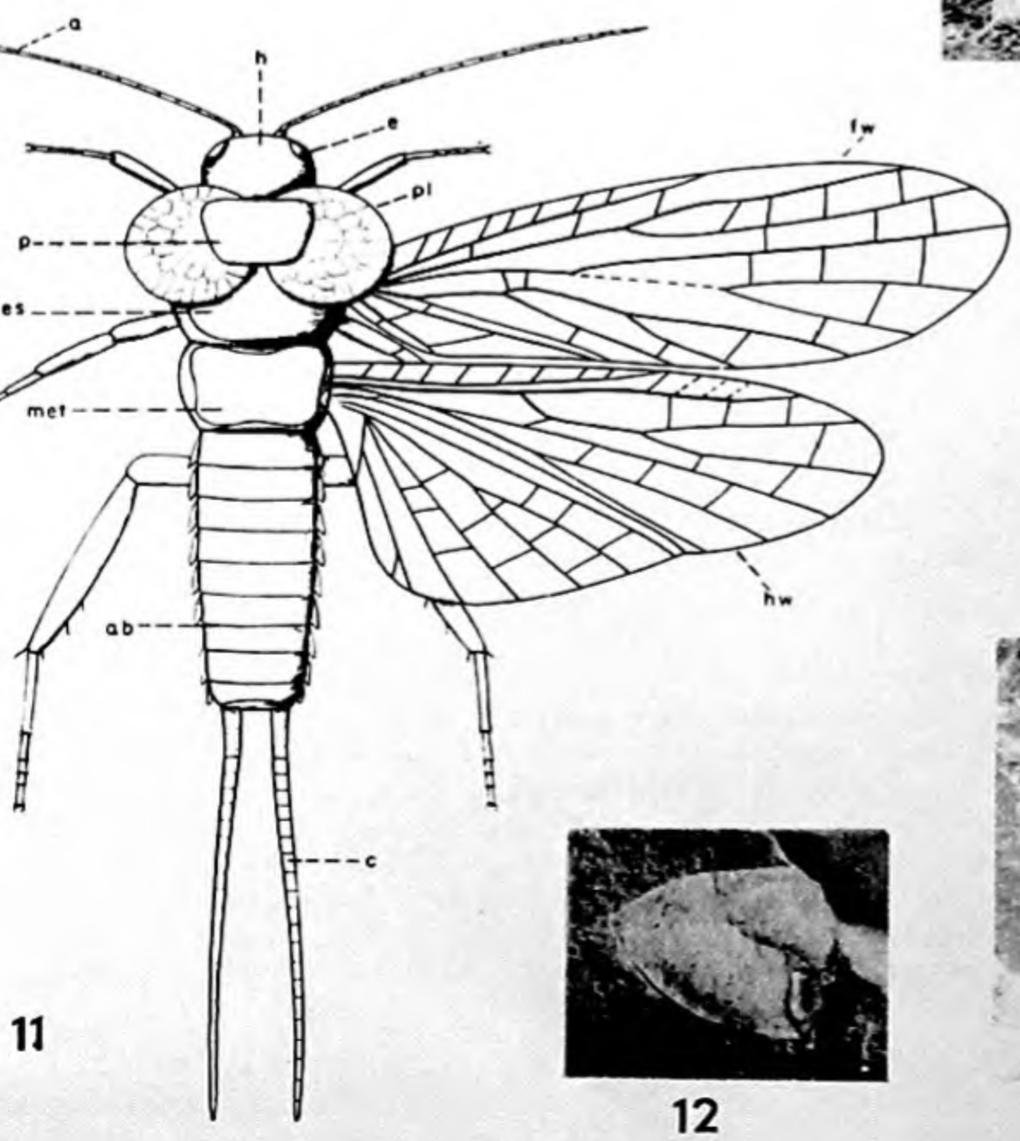

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cephalothorax and abdomen, division being behind the sixth pair of appendages; cephalothoracic segments usually fused, abdominal ones fused or free; six pairs of cephalothoracic appendages, first are chelicerae, second pedipalps, third to sixth inclusive are legs; abdomen lacks appendages.

Subclass Merostomata[1]

Arachnids with book-gills, and six pairs of walking legs about the mouth. **Camb.–Recent.**

Order Aglaspida. Merostomes with phosphatic exoskeleton consisting of a longitudinally trilobed dorsal shield and a longitudinally cleft postventral plate; dorsal shield comprises a cephalothoracic shield (*carapace*), and 12 abdominal segments, all freely articulating, or with postabdominal ones coalesced; the twelfth segment bears a long, spiniform posterior extension (telson spine) in one group; cephalothorax bears a pair of compound eyes and six pairs of uniramous, stenopodous, jointed appendages; first pair of appendages chelate, others simple and unspecialized; eyes variable in size and position. **Camb.**

AGLASPIS Hall 1862, emend Raasch 1939

(**A. barrandei*). Dorsal shield pustulose; eyes submedian, convex, moderately large, entire surface smooth; anterolateral border of carapace with conspicuous rim and doublure; shield indistinctly trilobed; glabellar area set off by relative convexity, not by dorsal furrow; occipital band present; genal angles acute to spiniform; paired postaxial nodes on segments and occipital band; 12 free abdominal segments. **U. Camb.** (U. Mississippi Valley).

A. spinifer Raasch (**298**—2, 3, 7). Characterized by prominent genal spine and spiniform postlateral extremities, respectively; telson spines distinct from all other species in wide spacing and uniform size of pustules. **Trempealeau:** Wis. (Lodi).

CHRASPEDOPS Raasch 1939

(**C. modesta*). Dorsal shield moderately convex with inconspicuous lobation; integument double, bipustulose, nearly smooth dorsally and finely but sharply pustulose ventrally; anterolateral doublure narrow; anterolateral rim narrow or absent; occipital band and furrow present; eyes large and of low convexity, anterior, moderately far apart, coarsely pustulose on summits and proximal-lateral slopes; glabellar area distinct, with secondary lobation and no dorsal furrow; abdominal segments marked by transverse furrows; telson rather short and rapidly tapering; differs from other aglaspids in eye position. **U. Camb.** (U. Mississippi Valley).

***C. modesta** Raasch (**298**—4, 8, 9). **Trempealeau:** Wis. (Lodi).

CYCLOPINA Raasch 1939

(**C. vulgaris*). Characterized by position of eyes, which are conjoined to form a transversely bilobed node lying medially near anterior edge of carapace, and strong vertical arcuation of shield, resulting in a sharply paraboloid vertical cross-section; rims and doublures on carapace apparently missing; paired tubercles near posterior edges of segments and carapace; dorsally pitted integument. **U. Camb.** (U. Mississippi Valley, Mont.).

***C. vulgaris** Raasch (**298**—5, 6, 12). **Trempealeau** (Lodi): Wis., Minn.

BECKWITHIA Resser 1931

(**B. typa*). Merostome with large cephalothorax having a flattened rim ending in genal spines; eyes rather large, situated well forward; eight abdominal segments; pleura bent down at considerable angle at middle and also rearward; pleural terminae bluntly truncated; spiniform telson with very large basal plate; cephalothoracic surface strongly pustulose, remainder of body more finely granulated. **M. Camb.**

***B. typa** Resser (**298**—1). **Marjum:** Utah.

Order Xiphosura. Exoskeleton trilobed, consisting of a horseshoe-shaped cephalothoracic carapace and distinct abdomen, of 7 to 10 segments, which terminates in a prominent telson; compound eyes, if

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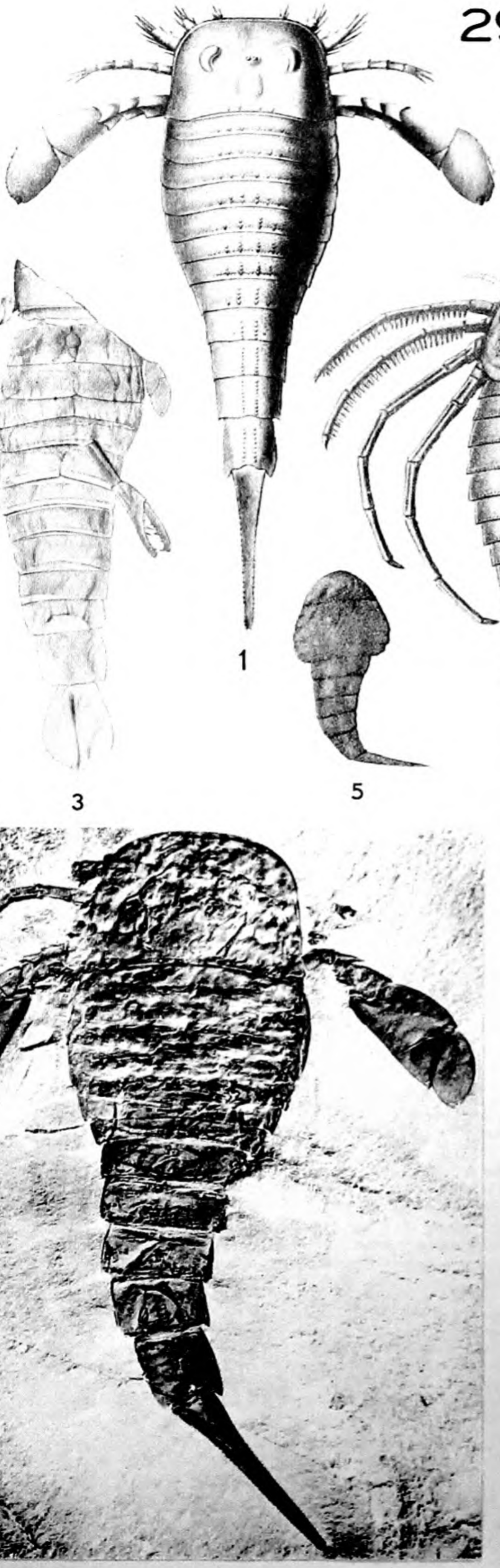
1939. **Resser, C. E.,** A new Middle Cambrian merostome: *USNM*, Pr 79 (33): 1–4, il, 1931. **Reudemann, R.,** Recent publications on Eurypterida: *AJS* (5) 7: 227–232, 1924. **Scudder, S. H.,** Illustrations of Carboniferous Arachnida of orders Anthracomarti and Pedipalpi: *Boston Soc N H*, M 4: 443–456, il, 1890; Index to the known fossil insects of the world, including myriapods and arachnids: *USGS*, B 71: 1–744, 1891.

[1] Our grateful acknowledgments are due Mr. G. O. Raasch for assistance in the revision of the Merostomata.

PLATE 298

[Figures are x1 and from Raasch [GSA, SP 19] unless otherwise indicated; photographs furnished by Raasch are indicated by GOR.]

1. Beckwithia typa (x1.7) [USNM, Pr 79]; photograph furnished by C. E. Resser]. **2, 3. Aglaspis spinifer.** Ventral impression of large carapace; a typical specimen. **4. Chraspedops modesta.** Entire dorsal shield, ventral impression (x2). **5, 6. Cyclopina vulgaris.** Left half of abdominal segment showing deep furrow behind articulating area (x1, x2). **7. Aglaspis spinifer.** Complete dorsal shield. **8, 9. Chraspedops modesta.** Dorsal shields (x3, x4), minus post-abdomen, ventral aspect. **10. Alpheus nigro-spinatus** (x3.5) [N Y Ac Sc, An 11]. A modern prawn from the Bahamas. The figure shows external organs at one side, i.e., the inner antenna with double flagellum, the outer with a single flagellum, the long third maxilliped, the large claw, or first pereiopod, the slender chelate second pereiopod with the carpus five-jointed (one long and four shorter joints); the third, fourth, and fifth pereiopods ending in spines (fourth one missing); the first five pleopoda; and the caudal fin. **11.** Restoration of *Lemmatophora* **(Order Protoperlaria),** from Permian (Wellington) of Kansas (*a*, antenna; *ab*, abdomen; *c*, cercus; *e*, eye; *fw*, fore wing; *h*, head; *hw*, hind wing; *mes*, mesothorax; *met*, metathorax; *p*, prothorax; *pl*, prothoracic lobe). [Original drawing by F. M. Carpenter.] **12. Cyclopina vulgaris** (x4). Cheek area of carapace, dorsal aspect, showing deflected lateral and posterior edges and minute genal spine. **13.** A cockroach wing from Permian (Wellington) of Kansas (x7) [photograph by F. M. Carpenter].



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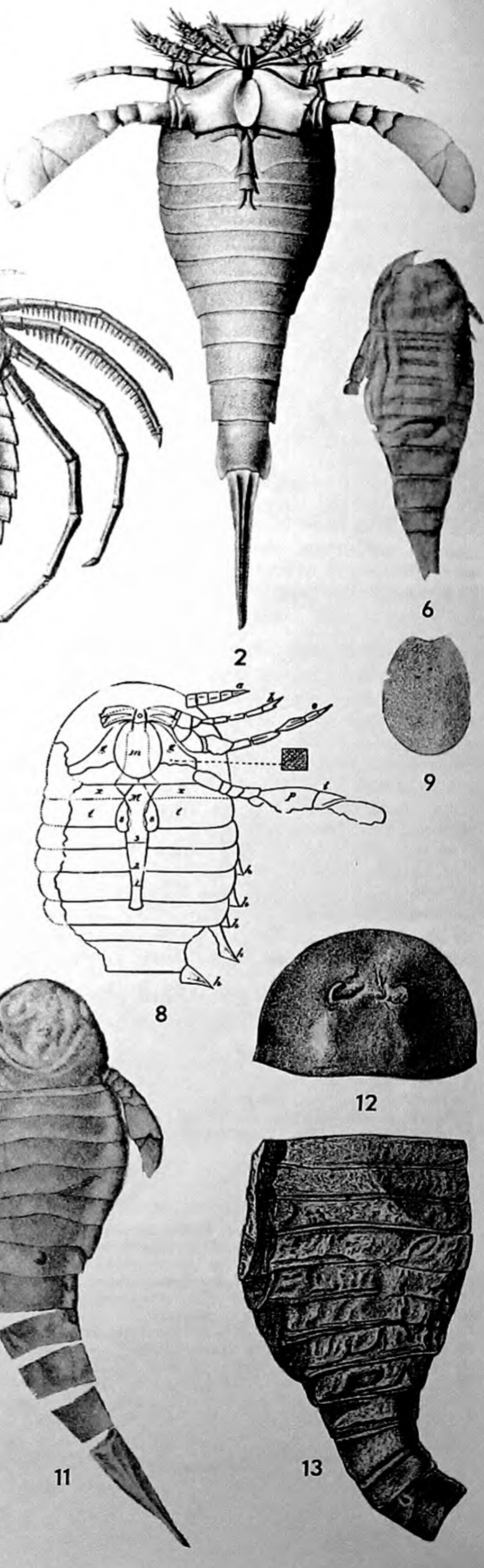

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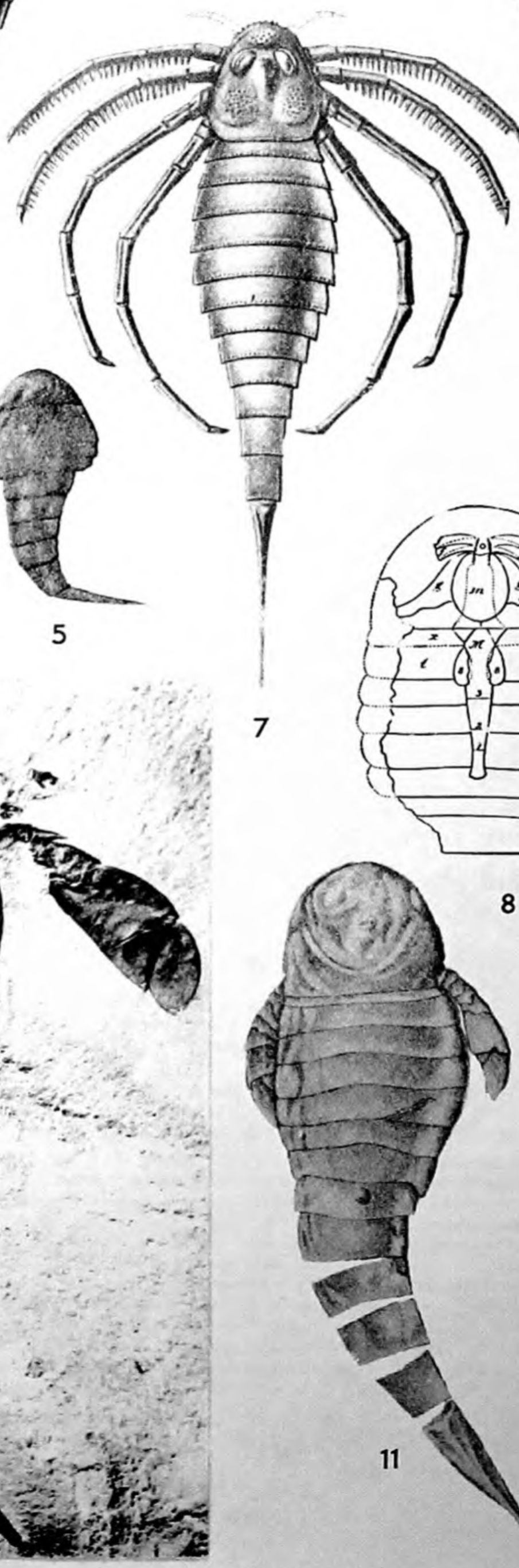

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present, lateral; ocelli near center in front. **Dev.–Recent.**

EUPROÖPS Meek 1867

(= PRESTWICHIA of authors)

(**Bellinurus danae* Meek and Worthen). Similar to modern *Limulus* (horseshoe crab), but much smaller, and with curved instead of straight ridges behind the eyes; the mid-shield has six rings on the axial lobe, the last an elevated boss. **U. Carb.** (N. America; Europe; Asia).

***E. danae** (M and W) (**300**—5). Prosoma (head) 2.5 to 3 times as broad as long. **Penn.** (Allegheny): Ind., Ill.

PALEOLIMULUS Dunbar 1923

(**P. avitus*). Differs from *Euproöps* in having straight ridges behind the eyes, and movable spines on the mid-shield. **Dev.–Perm.** (N. Y., Kan.).

***P. avitus** Dunbar (**300**—1, 2). **L. Perm.:** Kan. (Elmo).

LIMULUS Mueller 1785

(**Monoculus polyphemus* Linnaeus). This is the common "horseshoe crab" which lives along the Atlantic seaboard; its disintegrated shell is commonly found strewn along the beach sands. **Recent.** (**Mesozoic** in Europe; not known fossil in N. America.)

***L. polyphemus** (Linnaeus) (**300**—15–17). **Recent:** Widespread in present oceans.

Order Eurypterida. Large, crustacea-like forms, with an elongate body composed of *cephalothorax*, ringed *abdomen*, and *telson*; body covered by a chitinous exoskeleton which could be moulted as in the modern horseshoe crab; cephalothorax usually furnished dorsally with two large, faceted *lateral eyes* and a pair of *median ocelli*, and ventrally with six pairs of legs, the first preoral and chelate, the others nonchelate; abdomen of 13 joints, the six anterior segments bearing ventrally five pairs of broad leaflike appendages probably comparable to the "gill-books" and operculum of the Xiphosura and the posterior seven segments, including telson, without appendages; last pair of legs usually large and somewhat flattened, ending in an oval plate resembling a paddle; ventral surface of first two abdominal segments with genital *operculum* — a pair of plates meeting medially with a median lobe attached which differs in the two sexes: eurypterids were probably mostly fresh-water or brackish water animals for their remains are rare in typical marine strata. **Camb.–Perm.;** commonest in **Sil.**

EURYPTERUS Dekay 1825

(**E. remipes*). Body elongate and narrow, often large; cephalothorax one-seventh to one-fifth of entire length including telson, depressed-convex, subquadrate in outline, with anterior angles rounded and posterior margin slightly concave; entire margin bordered by narrow, marginal furrow; eyes bean-shaped, situated somewhat in front of middle of cephalothorax; ocelli close to median line; mouth a ventral cleft; legs progressively increasing in length backward, the anterior pair small and chelate; second, third and fourth pairs six- or seven-jointed, and finely spinose; fifth pair eight-jointed; posterior (sixth) pair consisting of eight segments, large and powerful, with a large, subquadrate basal joint in each and a broad terminal paddle; anterior six segments of abdomen occupying together about one-fourth of entire body length; they are short, broad and of nearly uniform shape; the succeeding segments are ringlike and progressively decrease in diameter, thus causing a tapering of the body; telson long and slender. **Ord.–Perm.**

***E. remipes** Dekay (**299**—1, 2). **U. Sil.:** N. Y. (Bertie).

E. lacustris Harlan (**299**—10). Stout; anterior portion of abdomen very broad, abruptly tapering beyond sixth segment; next to last segment quadrate, without lateral flanges. **U. Sil.:** Ont.; N. Y. (Bertie).

E. microphthalmus Hall (= **E. eriensis** of authors) (**299**—12, 13). Cephalothorax semioval, regularly rounded; eyes small, rather close together; abdomen scarcely widening to fourth segment, after which it tapers rapidly; last three segments of nearly equal width. **U. Sil.:** N. Y., Pa., Ohio (Monroan).

ANTHRACONECTES Meek and Worthen 1868

(**Eurypterus* (*Anthraconectes*) *mazonensis*). Like *Eurypterus*, but with spines on falcate posterior angles of abdominal segments. **Penn.** (Pa., Ill.).

***A. mazonensis** (M and W) (**299**—8, 9). **Penn.:** Ill.

STYLONURUS Page 1856

(**S. powriei*). Very large; body similar in general proportions to *Eurypterus*; prosoma quadrate; eyes large, ocelli on slope of median ridge; preoral appendages chelicerate; the five pairs of postoral appendages greatly elongated; telson long and slender. **Sil., Dev.** (eastern N. America; Scotland; Russia).

PLATE 299

[Figures are x1 unless otherwise indicated.]

1, 2. Eurypterus remipes (x0.5) [N Y St Mus, M 14]. Dorsal and ventral views. **3, 4. Pterygotus macrophthalmus** (x0.5) [N Y St Mus, M 14]. A nearly complete specimen, and one of the chelate appendages. **5, 6. Hughmilleria shawangunk** [N Y St Mus, B 107]. A young individual, 2.5 mm long; a nearly complete individual, 40 mm long. **7. Stylonurus (Ctenopterus) cestrotus** (x0.7) [AMNH, J 26; N Y St Mus, M 14]. Restoration of dorsal side. **8, 9. Anthraconectes mazonensis** [Ill G S 3]. Ventral view (x0.5) showing numerous appendages; hypostoma (x1) showing surface sculpturing. **10. Eurypterus lacustris** (x0.5) [N Y St Mus, M 14]. **11. Hughmilleria socialis** [N Y St Mus, B 69]. Dorsal view of a specimen below average size. **12, 13. Eurypterus microphthalmus** [Ohio G S 7].

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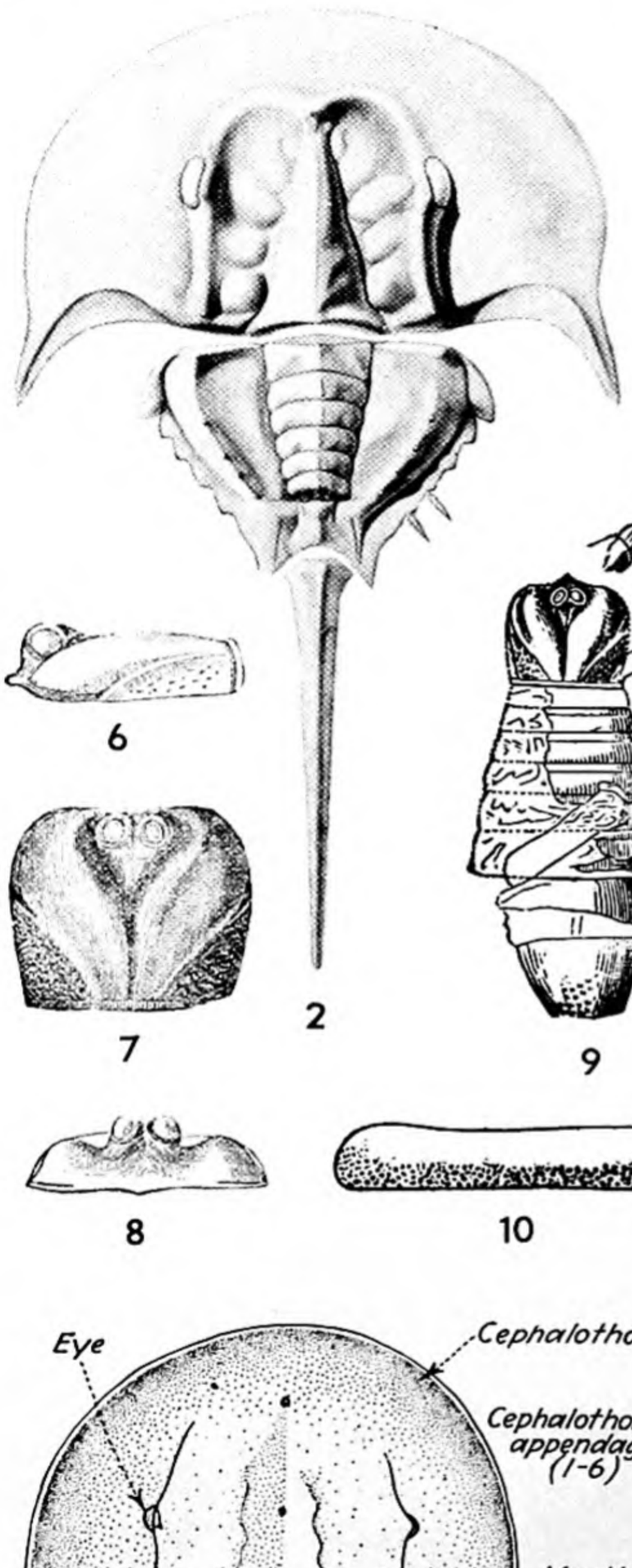

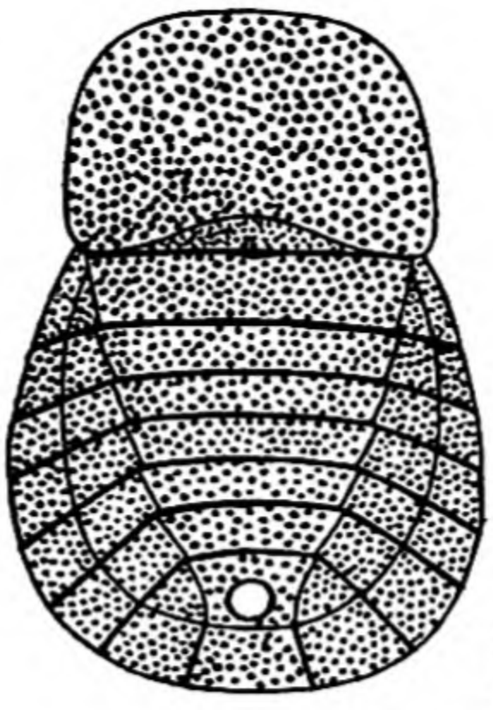

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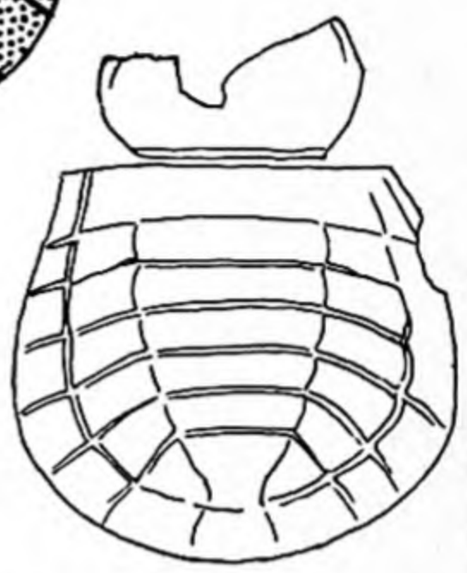

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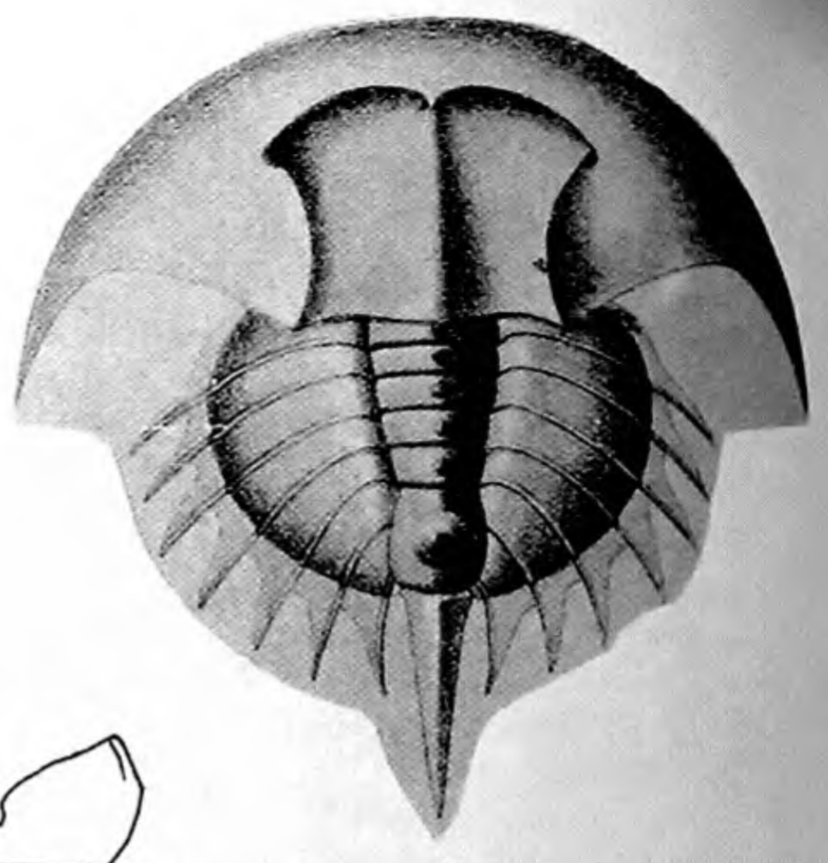

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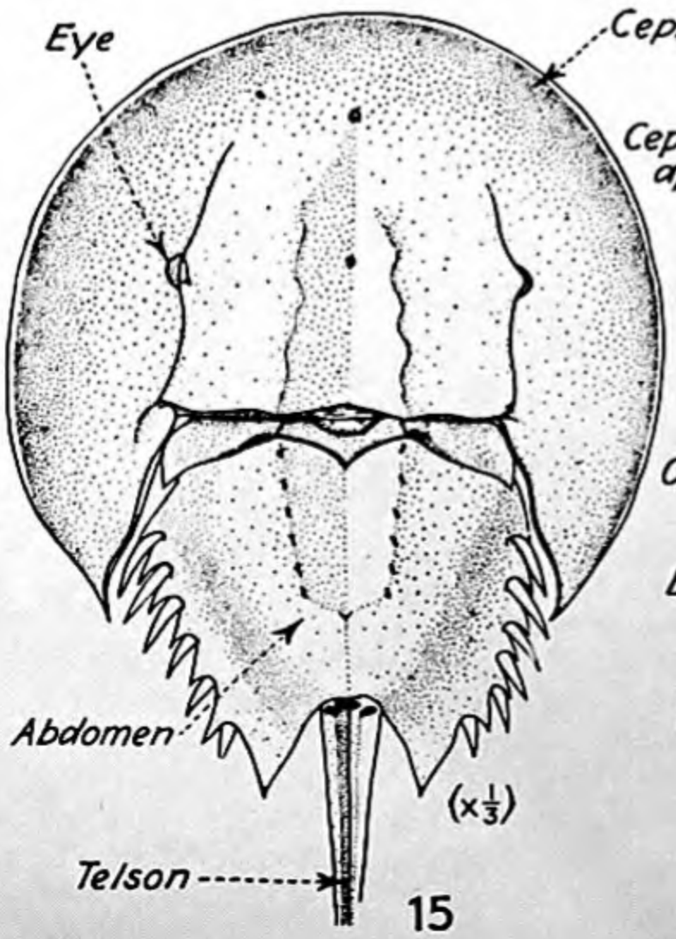

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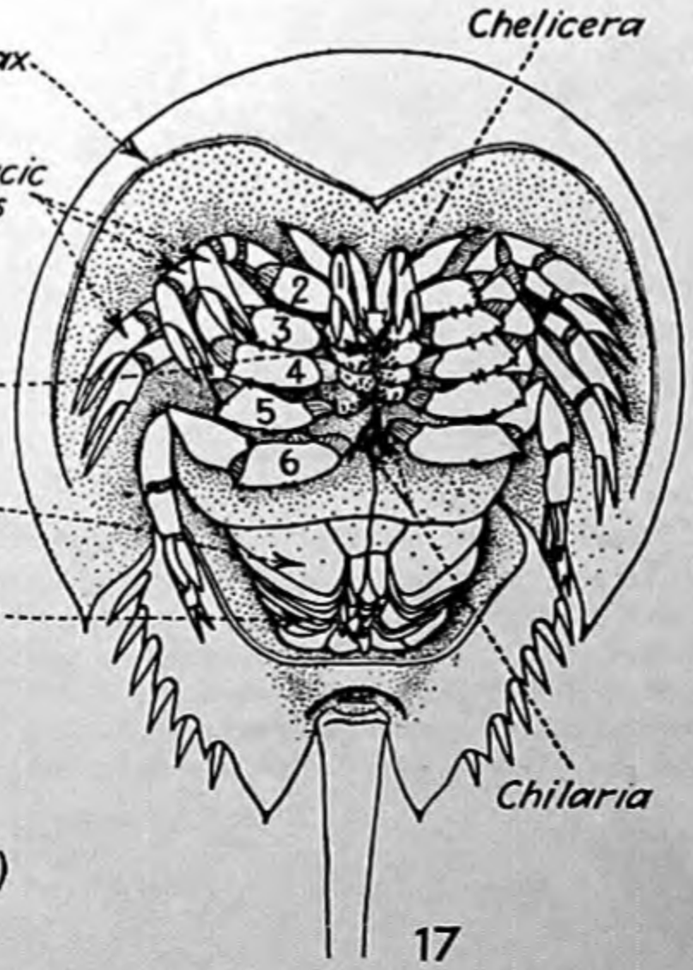

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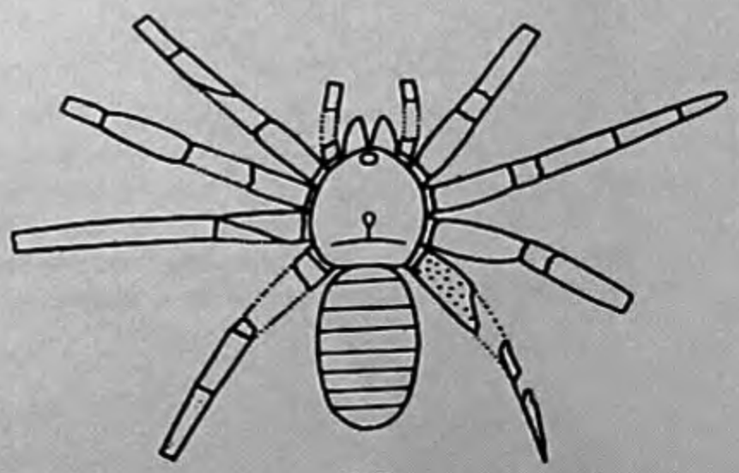

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S. (Ctenopterus) cestrotus (Clarke) (**299**—7). First three pairs of legs with numerous paired spines to each segment. **L. Sil.:** N. Y. (Shawangunk).

PTERYGOTUS Agassiz 1839

(**P. problematicus*). Differs from *Eurypterus* in having eyes marginal instead of within the carapace, 12 instead of 13 segments in body, a bilobate caudal extremity, and chelate antennae at anterior part of carapace; very large, with length of over 2 m (6 ft). **Ord.** (N. Y.); **Sil.** (U. S. A.; Wales; Scotland; Sweden and Oesel; Russia; Australia); **Dev.** (Scotland).

P. macrophthalmus Hall (**299**—3, 4). **U. Sil.** (Cayugan): N. Y. (Bertie).

HUGHMILLERIA Sarle 1903

(**H. socialis*). Small arachnids with carapace as in *Pterygotus*, chelate appendages on short legs, and telson as in *Eurypterus*; epistoma lyre-shaped, flanked by lateral shields. **Ord., Sil.** (eastern U. S. A.).

***H. socialis** Sarle (**299**—11). Telson comparatively long and pointed; surface of entire carapace covered with imbricating, crescentic or angular scales, in some species carrying smaller ones of same pattern. **U. Sil.:** N. Y. (Pittsford).

H. shawangunk Clarke (**299**—5, 6). **Shawangunk:** N. Y., Pa.

Subclass Embolobranchiata

Terrestrial arachnids with respiration by book-lungs or tracheae; cephalothorax usually without dorsal indications of segments, but there are six pairs of cephalothoracic legs surrounding the mouth, at least four of which are used for walking; fossil record very sparse. **Sil.–Recent.**

EOSCORPIUS Meek and Worthen 1868

(**E. carbonarius*). Cephalothorax quadrangular with mesial and lateral furrows between which surface is granulose; mandibles stout, nonserrate; movable finger curved and sharp at point; legs stout, divisions long; abdomen twice as long as cephalothorax and with seven segments, the last very long and tapering backward to truncated extremity where tail is attached; tail incomplete. **Penn.** (central U. S. A.).

***E. carbonarius** M and W (**300**—10–12). **Penn.:** Ill.

MAZONIA Meek and Worthen 1868

(**M. woodiana*). Cephalothorax moderately convex, subquadrangular; anterolateral margins rounded, and anterior margin truncated on each side of a mesial triangular projection; mesial furrow extends forward from posterior margin, widening and deepening to front, where it occupies a third of the width and is partly filled by an oculiferous prominence, which bears a large eye on each side; eyes circular, convex; abdominal segments seven or eight, the last one truncated for the tail. **Penn.** (Ill., Kan.).

***M. woodiana** M and W (**300**—6–9). **Penn.:** Ill.

ARTHROLYCOSA Harger 1874

(**A. antiqua*). Cephalothorax orbicular, twice as large as abdomen; coxae radiating from a central pit; abdomen oval, much narrower at base than cephalothorax, without longitudinal sculpturing, and composed of seven segments; no abdominal appendages. **Penn.** (central U. S. A.)

***A. antiqua** Harger (**300**—18). **Penn.:** Ill.

ANTHRACOMARTUS Karsch 1882

(**A. volkelianus*). Cephalothorax quadrate, about half the size of the abdomen; coxae radiating from a broad, triangular sternal plate, of which the base forms the posterior margin; sides of body constricted so as to show a slight separation of cephalothorax and abdomen; abdomen orbicular, composed of seven segments of similar length throughout. **Penn.** (central U. S. A.).

A. trilobitus Scudder (**300**—3, 4). **Penn.:** Ark. (Pottsville).

PLATE 300

[Figures are x1 unless otherwise indicated.]

1, 2. Paleolimulus avitus (x5) [AJS (5) 5]. Restoration of ventral side of cephalothorax; dorsal view of complete specimen, restored. **3, 4. Anthracomartus trilobitus.** 3: Restoration (x4) [Conn Ac, Tr 18]. 4: Outline (x3) [Bos Soc N H, M 4]. **5. Euproöps danae** [Nat Ac Sc, M 3]. **6–9. Mazonia woodiana** [Ill G S 3]. Side, dorsal, and anterior views of cephalothorax (x2), showing large eyes and medial prominence; an incomplete specimen. **10–12. Eoscorpius carbonarius** [Ill G S 3]. Body segment enlarged; the holotype; comb (pecten) enlarged. **13, 14. Paradoxides davidis** [photographs furnished by B. F. Howell] (also see **254**—12, 13). Incomplete cranidium; pygidium with several thoracic segments attached. **15–17. Limulus polyphemus** [after Twenhofel and Shrock, "Invertebrate Paleontology," by permission of McGraw-Hill Book Co., Inc.]. The modern horseshoe crab, viewed dorsally and ventrally, with a small drawing showing the length of the telson. **18. Arthrolycosa antiqua** [Conn Ac, Tr 18]. Restoration.

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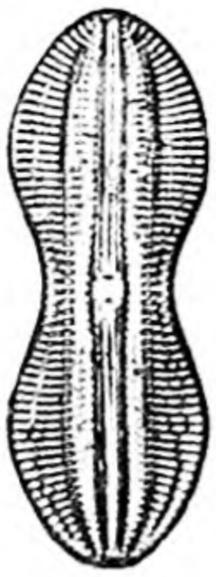
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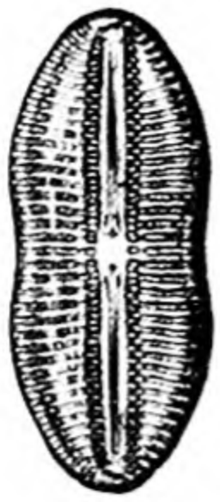
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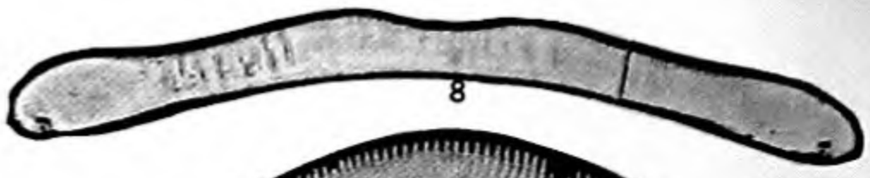
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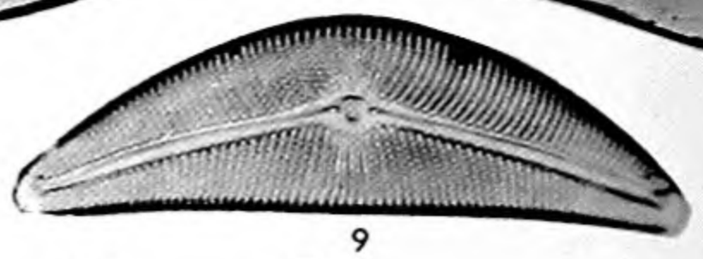
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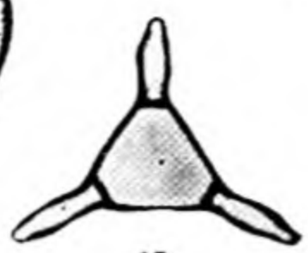
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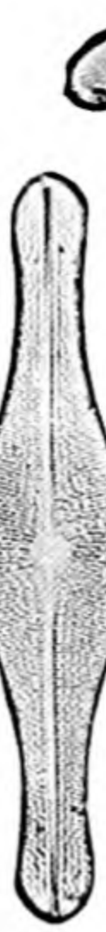
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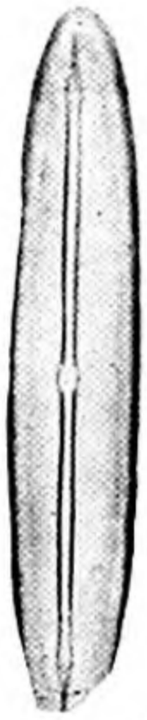
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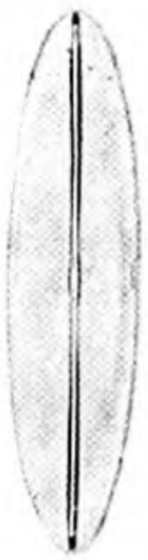
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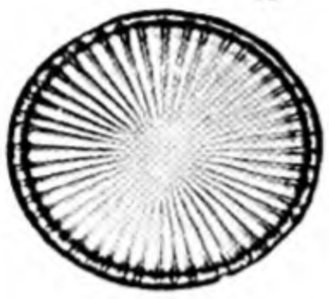
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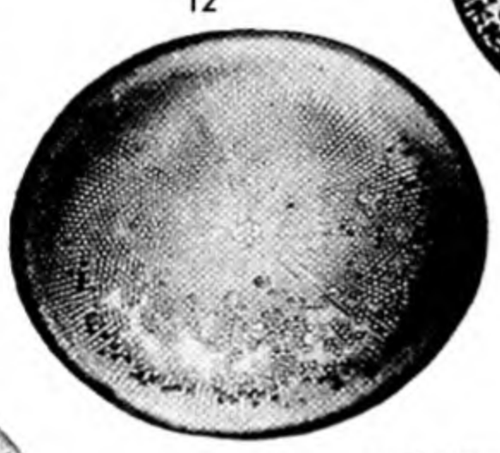
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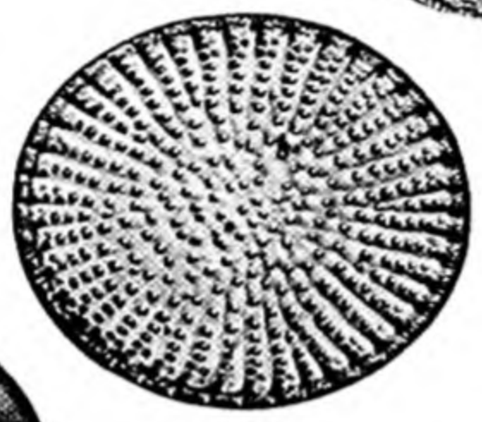
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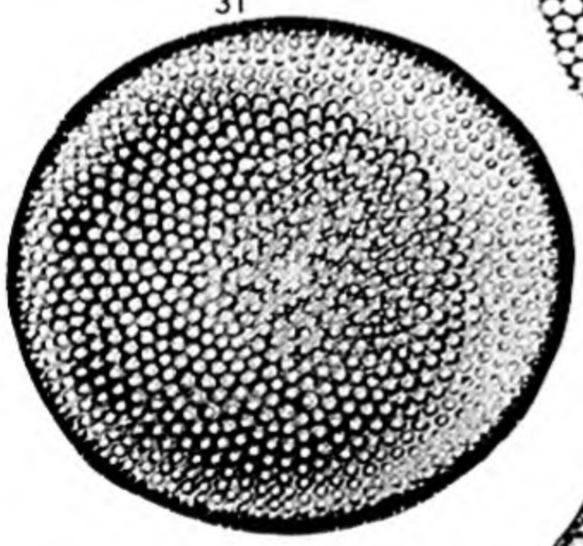
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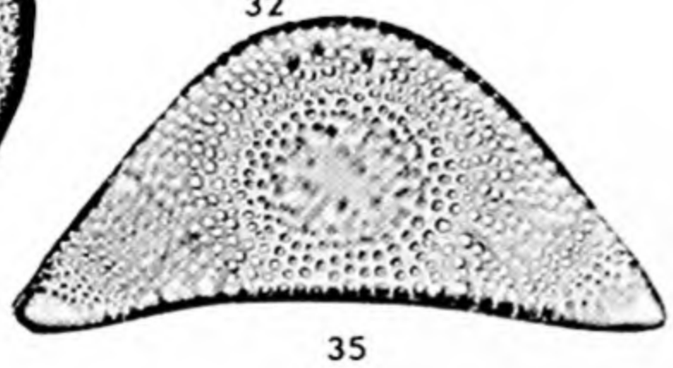
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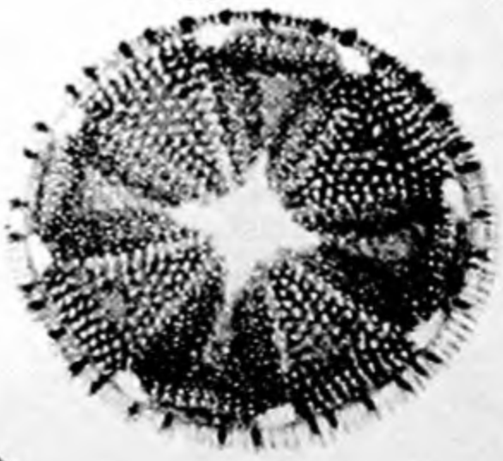
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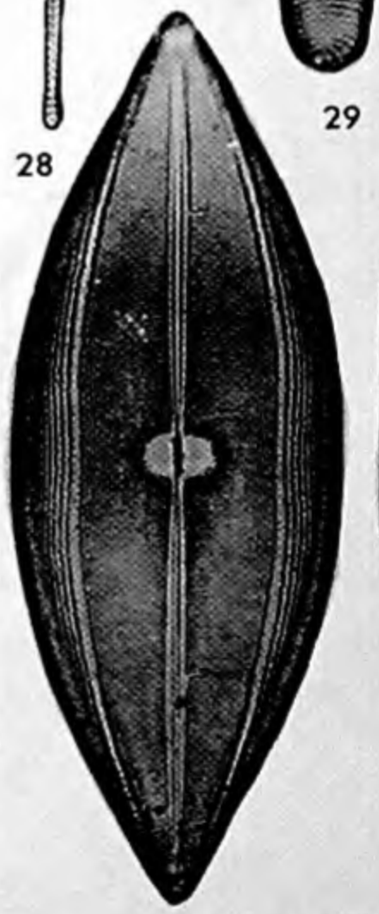
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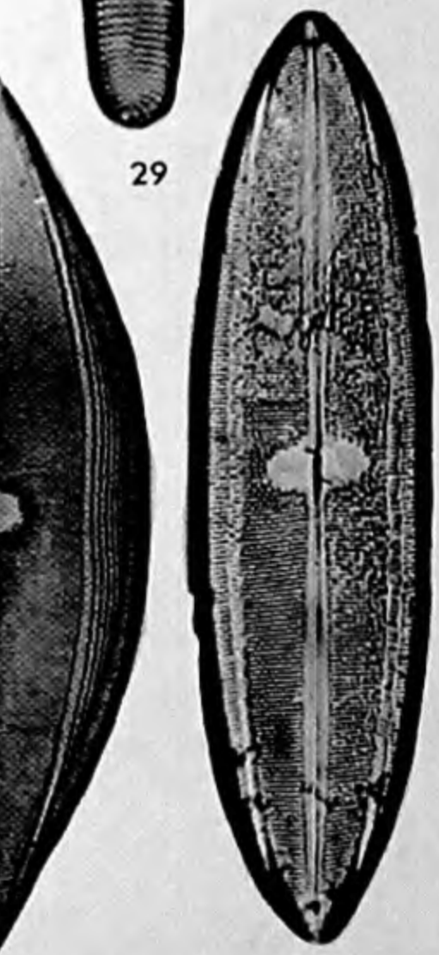
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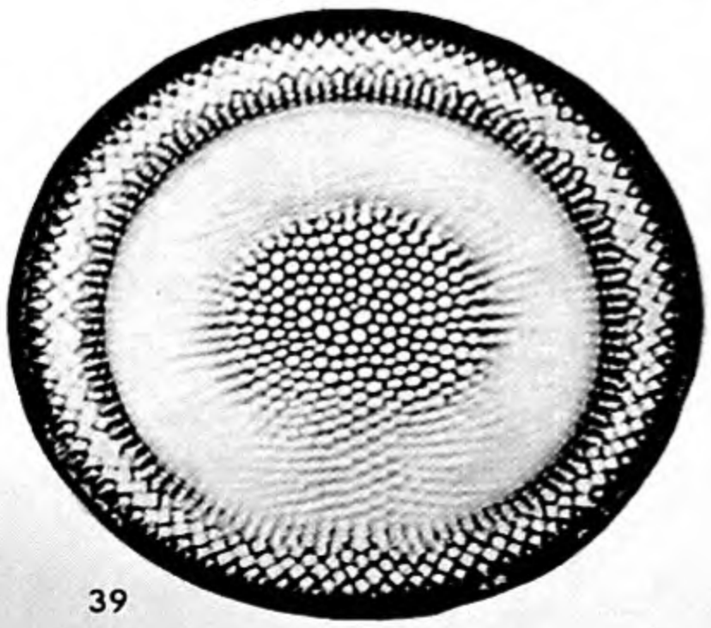
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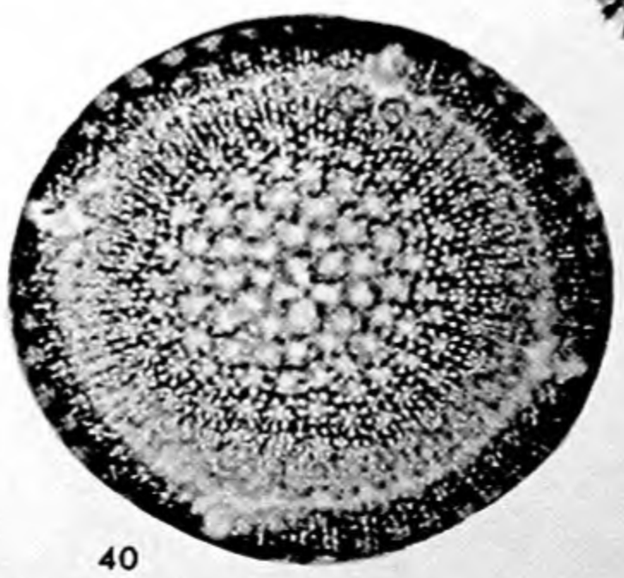
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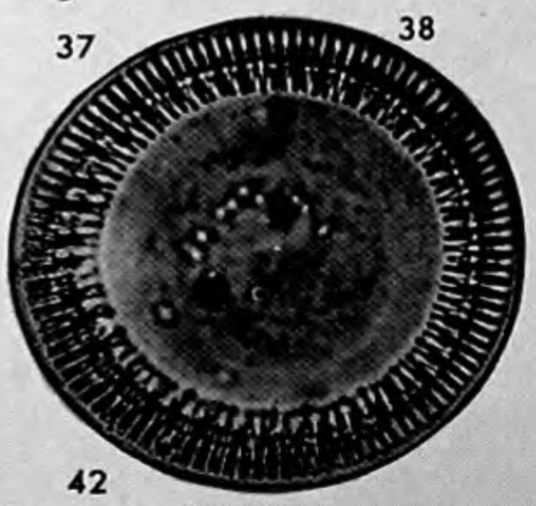
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CHAPTER XII

FOSSIL PLANTS

The fossil record of plants is a rich and varied one and reaches as far back into geologic history as that of animals, though it is sparse and of little value to the field geologist if he is working with strata older than the Pennsylvanian. Furthermore, the best preserved plant fossils usually are found in continental terrestrial and fresh-water deposits, and since these are not so common or so widespread as marine strata, plant remains are not so frequently encountered as animal remains.

PLATE 301

Explanatory Remarks and Acknowledgments. Figs, 1–27, 29, 30, 37, 38, 41, and 42 were furnished by G. Dallas Hanna. The photomicrographs are original unless the place of publication is indicated in brackets.

California and Nevada specimens are preserved in the Paleontological Type Collection of the California Academy of Sciences and are numbered as indicated here (H = hypotype; P = paratype). The locality numbers (Loc 943) are those of the same Academy.

The Florida hypotypes are preserved in the Florida Geological Survey All of them were illustrated in the Fla G S, An Rp 23–24, 1933.

Figs. 28, 31–36, 39, and 40 are specimens from the Miocene of Maryland and are preserved in the Diatom Collections of the New York Botanical Garden. The photomicrographs are by Richard F. Lawrence and were made with the assistance of Joseph F. Burke.

Measurements are given in microns. L = length; W = width; D = diameter.

The stratigraphic range of most genera is indicated at the end of the tabulated data.

1. Hemiaulus claviger Schmidt [JP 1]. L = 100; W = 44. Marine. H3053; Loc 894. Kreyenhagen: Cal. Olig.–Recent. **2. Diploneis exempta Schmidt.** L = 115; W = 37. Marine and fresh-water genus. H3354; Loc 866. U. Monterey: Cal. Mioc.–Recent. **3. Diploneis ornata Schmidt.** L = 144; W = 55. Marine and fresh-water genus. H3355; Loc 866. U. Monterey: Cal. Mioc. only. **4. Meretrosulus gracilis Hanna** [Cal Ac Sc, Oc P 13]. L = 59. Marine. P2020; Loc 943, U. Cret.: Cal. (U. Moreno). U. Cret. **5. Auliscus californicus Brun** [Eng Min J 1930]. D = 78. Marine. H3353a; Loc 1277. U. Monterey: Cal. **6, 7. Rhaphoneis angularis Lohman.** 6. L = 55; W = 22. Marine. H3352; Loc 26482. 7. L = 84; W = 20. H3352a. Both about 100 feet below Mulinia zone in the Plioc. (Etchegoin) of Cal. Plioc. **8. Eunotia diodon Ehrenberg.** L = 160. Fresh-water. Pleist.: Fla. Late Tert.–Recent. **9. Cymbella mexicana Ehrenberg** [Am Micr Soc, Tr 50]. L = 96. A Recent specimen from Pyramid Lake, Nev. H3294. Fresh-water deposits, Tert.–Recent. **10. Entopyla australis Ehrenberg.** L = 144; W = 29. Marine. H3356; Loc 866. U. Monterey: Cal. Mioc.–Recent. **11. Triceratium montereyi Brightwell.** L (one side) = 140. Marine. H3360; Loc 866. U. Monterey: Cal. Olig.–Plioc., Recent? **12. Melosira clavigera Grunow.** D = 66. Marine and fresh-water genus, marine species. H3358; Loc 866. U. Monterey: Cal. Olig.–Plioc. **13. Cymatogonia amblyoceras Ehrenberg** [Cal Ac Sc, Pr 20]. L (one side) = 90. Marine. H3178; Loc 1068. M. Mioc.: Cal. (Temblor). **14. Xanthiopyxis umbonata Greville.** D = 80. Marine. H3361; Loc 866. U. Monterey: Cal. Mioc. **15. Lithodesmium cornigerum Brun** [JP 4]. Distance between tips of two arms, 64 μ. Marine. H3136; Loc 1220. Plioc.: Cal. U. Mioc., L. Plioc. **16. Glyphodiscus stellatus Greville.** D = 75. Marine. H3357; Loc 866. U. Monterey: Cal. Olig.–U. Mioc. **17. Anomoeoneis follis (Ehrenberg) Cleve.** L = 106. Fresh-water. Species of this genus are often referred to *Navicula*. Pleist.: Fla. Pleist–Recent. **18. Pinnularia major (Kützing) Cleve.** L = 215. Fresh-water. Species of this genus are often referred to *Navicula*. Pleist.: Fla. Mioc.–Recent. **19. Pinnularia viridis (Nitzsch) Cleve.** L = 90. Fresh-water. Pleist.: Fla. Mioc.–Recent. **20. Surirella oblonga Ehrenberg.** L = 181. Fresh-water and marine genus. Fresh-water species. Pleist.: Fla. Pleist.–Recent. **21, 22. Frustulia lewisiana (Greville) De Toni.** 21. L = 257; W = 44. Brackish and fresh-water genus. H3351; Loc 26482. Plioc. (Etchegoin): Cal. (100 ft below Mulinia zone). 22. L = 126; W = 29. A living specimen from Bolinos Bay, Cal., showing characteristic markings. H3353. Plioc.–Recent. **23. Coscinodiscus asteromphalus Ehrenberg.** D = 273. Marine. H3350; Loc 26482. Plioc. (Etchegoin): Cal. (100 ft below Mulinia zone). Mioc.–Recent. **24. Stictodiscus californicus Greville.** D = 51. Marine. H3359; Loc 866. U. Monterey: Cal. Mioc. **25. Cocconeis baldjikiana Grunow.** L = 72; W = 38. Marine and fresh-water genus, marine species. H3349; Loc 26482. Plioc. (Etchegoin): Cal. (100 ft below Mulinia zone). Mioc.–Recent. **26. Melosira granulata (Ehrenberg) Ralfs.** L = 114; W = 17. Marine and fresh-water genus, fresh-water species. H3362; Loc 26863. U. Plioc.: Cal. Mioc.–Recent. **27. Rutilaria epsilon Greville** [AAPG, B 12]. L = 152; W = 25. Marine. H3095; Loc 866. U. Monterey: Cal. Olig.–Recent. **28. Sceptroneis caduceа Ehrenberg.** L = 180. Cloud S–68. Mioc.: Md. Abundant in M. Mioc. only in U. S. A.; extremely rare as Recent along coast of Europe. **29. Fragilaria floridana Hanna.** L = 45. Fresh-water. Pleist.: Fla. **30. Melosira granulata (Ehrenberg) Ralfs.** D = 20. Fresh-water. Pleist.: Fla. Mioc.–Recent. **31. Raphidodiscus marylandicus Christian.** D = 35. Marine. Ward A–19–16. Mioc.: Md. **32. Craspedodiscus coscinodiscus Ehrenberg.** D = 105. Marine. Poyser 11–15. Mioc.: Md. M. Mioc. (common)–Recent (rare). **33. Rattrayella inconspicua (Rattray) Hanna.** D = 90. Marine. Poyser 11–19. Mioc.: Md. **34. Coscinodiscus apiculatus Ehrenberg.** D = 105. Marine. Cloud S–67. Mioc.: Md. M. Mioc. (common)–Recent? **35. Triceratium semicirculare Brightwell.** D = 110. Marine. Cloud S–65. Mioc.: Md. **36. Actinoptychus heliopelta Grunow.** D = 167. Marine. Cloud S–64. Mioc.: Md. **37. Neidium tumescens (Grunow) Cleve.** L = 232. Fresh-water. Species of this genus are often referred to *Navicula*. Pleist.: Fla. Pleist.–Recent. **38. Neidium iridis (Ehrenberg) Cleve.** L = 120. Fresh-water. Pleist.: Fla. L. Plioc.–Recent. **39. Craspedodiscus elegans Ehrenberg.** D = 215. Marine. Ward A–46–4. Mioc.: Md. **40. Aulacodiscus rogersii (Bailey).** D = 110. Marine. Cloud–66. Mioc.: Md. **41. Stephanodiscus astraea (Ehrenberg) Grunow.** D = 51. Marine, brackish, and fresh-water. Pleist.: Fla. Mioc.–Recent. **42. Cyclotella quillensis Bailey** [Am Micr Soc, Tr 50]. D = 47. A recent specimen from Pyramid Lake, Nev. Genus occurs in Pleist.–Recent fresh-water deposits and is also marine. H3293.

There are certain fossil plants, however, which, because of their microscopic size, wide distribution, importance as rock builders, or value as correlating devices, deserve consideration even in a book such as the present one which obviously is devoted to fossil animals almost exclusively. These are the diatoms, charophytes, and algal structures. All are common and certain to become of much greater importance in the future. Petroleum geologists are already using them with considerable profit, and additional study will certainly show that they have even greater value as index fossils. We shall consider only a very few of the better known and more common genera, the purpose being to acquaint the beginner with fossil plants and structures made by ancient plants, so that his interest and curiosity will be stimulated to do further work on them.

DIATOMACEAE [1,2]

At the present time diatoms (unicellular plants) are living in almost all waters except those of extremely high salinity or temperature. They are especially prolific in polar regions, and constitute one of the chief basic sources of food for all marine animals. About 20,000 species, living and fossil, included in over 600 genera have been described. Since diatoms are largely pelagic, many species are widely dispersed in marine and fresh waters. Very few species, if indeed any, are able to live in both habitats; hence it is usually easy to differentiate between marine and fresh-water diatomaceous sediments.

Long slender forms predominate in many fresh-water deposits, and in most lakes today, whereas most marine forms are circular; but shape alone is not a reliable guide for discrimination.

No fresh-water diatomaceous deposits older than the Tertiary are known, and the oldest of marine origin are Upper Cretaceous. The group must have evolved earlier, however, for the Cretaceous forms are highly developed and are represented by a large number of genera and species.

Diatoms rank rather high as indicators of zones and formations, but preservation has often been difficult if not impossible because of the nature of the skeletal material. This is organic, opaline silica which is extremely unstable as a rock-building constituent. It is particularly susceptible to compaction and alteration to cherty substances, with consequent destruction of the sculpture and usually the form of the skeleton.

The accompanying plate (**301**) shows a few of the commoner types of diatoms that may be expected in marine, brackish, and fresh-water deposits.

CHAROPHYTA[3]

PREPARED BY RAYMOND E. PECK

Charophyta are small bushy plants ranging from about 10 cm (4 in.) to 60 cm (2 ft) in height. They occur abundantly in quiet, clear, fresh-water bodies, like ponds, ditches, and lakes, and are distributed widely throughout the world. The outstanding characteristics of the group are the male and female reproductive organs, termed the *antheridia* and *oogonia*, respectively, and the whorled lateral branches on which the organs are borne. Some species secrete calcium carbonate and are large contributors to fresh-water limestones.

Fossil Charophyta are exclusively oogonia. Vegetative parts are seldom preserved but have been recorded from the Purbeck (Jurassic) of England by Harris and from the early Tertiary near Triest, Italy, by Stache. Vegetative parts that probably belong to the Charophyta have been collected from the Morrison of Colorado and the Kootenai (L. Cret.) of Montana by Peck. Antheridia do not calcify, but fossil forms identified as antheridia have been described from the Purbeck of England by Harris and from the Lower Cretaceous of the United States by Peck.

Charophyte oogonia are composed of 5 (Penn.–Recent), or 6 to 11 (Dev., Miss.), long, rounded cells (enveloping cells, spiral cells, spiral units) that originate around a basal opening and ascend vertically (*Sycidium*), or in a dextral (*Trochiliscus*) or sinistral (Characeae) spiral to inclose com-

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[1] Dr. G. Dallas Hanna, California Academy of Sciences, prepared the copy on which the present introductory discussion is based, and also furnished the illustrations of the Florida, Nevada, and California specimens. Mr. Joseph F. Burke, Staten Island Institute of Arts and Sciences, arranged for the illustrations of the Maryland specimens, and Mr. Richard F. Lawrence, New York Microscopical Society, made the photomicrographs of these. Dr. K. E. Lohman, U. S. Geological Survey, read the typescript and made several valuable suggestions. It is a pleasure to acknowledge the indispensable aid of these investigators, and the cooperation of the institutions they represent.

[2] A vast literature of several thousand titles deals with the general subject of Diatoms, but for the present purpose it suffices to indicate only the following four large works: **Mills, F. W.,** An index to the genera and species of the Diatomaceae, p 1–1726, 1933–1935. **Pantocsek, J.,** Beiträge zur Kenntniss der fossilen bacillarien Ungarns, 3 pts, p 1–316, pl 1–102, 1886–1893. **Schmidt, A., Atlas** der Diatomaceekunde, pl 1–408, 1874–1936. **Van Heurck, H.,** A treatise on the Diatomaceae, p 1–558, pl 1–35 and 291 text figs, London, 1896.

[3] **Groves, J.,** Charophyta: *Fos Cat*, Plantae, No. 28, 1933 (contains a complete bibliography). **Harris, T. M.,** British Purbeck Charophyta: *British Mus Nat Hist*, 1939. **Karpinsky, A.,** Die Trochilisken: *Mem Com Geol* (n s), L 27, 1906. **Matthew, G. F.,** Lacustrine formation of Torryburn Valley [N. B.]: *N H Soc N B*, B 1 (2): 1–20, il, 1883. **Peck, R. E.,** North American trochiliscids, Paleozoic Charophyta: *JP* 8: 83–119, il, 1934; Morrison Charophyta from Wyoming: *JP* 11: 83–90, il, 1937; Lower Cretaceous Rocky Mountain nonmarine microfossils: *JP* 15: 285–304, il, 1941. **Rao, K. S.,** and **S. R.,** Fossil Charophyta of the Deccan Inter-Trappeans near Rajahmundry: *Pal Indica, Mem Geol Surv of India* 29, 1939. **Reid, C.,** and **Groves, J.,** Charophyta of the lower Headon beds of Hordle Cliffs: *GSL*, QJ 77: 175–192, il, 1921. **Stache, G.,** Die Liburnische Stufe: *Abhandl Geol Reichsanst* 13, 1889.

pletely a central cavity containing the oospore. At maturity calcite is deposited along the concave inner walls of the enveloping cells. Here it may form a thin deposit which results, upon preservation, in *cellular furrows* (**303**—6, 9); it may almost completely replace the cell contents to form *cellular ridges* (**303**—1, 5); or the deposition may stop between the two extremes. In modern charophytes 5 (Charae) or 10 (Nitellae) small crown *coronula* cells (**303**—2, 5, 8) rest on the distal ends of the enveloping cells. The coronula cells do not secrete calcium carbonate in living charophytes, but have been recorded on dextrally spiralled oogonia (*Trochiliscus*) by Peck and have been made the basis of the genus *Aclistochara* — sinistrally spiralled oogonia that range from Pennsylvanian to Tertiary.

Fossil oogonia are widely distributed in the Middle and Upper Devonian of North America, occur sparsely in the Mississippian and Pennsylvanian, are abundant in the Morrison (Jurassic), the fresh-water Lower and Upper Cretaceous (Bear River, Gannett, Kootenai, parts of the Trinity) and in the Rocky Mountain and Gulf Coast Tertiary. They occur in limestones and calcareous shales and are easily obtained by washing samples from shales or shale partings in or near fresh-water limestones. They are of greatest stratigraphic value from Jurassic to Eocene. Those occurring in rocks younger than Eocene are similar to modern forms and are difficult to distinguish and identify.

About 250 species of fossil Charophyta have been named from various parts of the world. Less than 50 of these have been described from North America. Only those of exceptional stratigraphic value or widespread distribution are included here.

CHARA Vaillant 1719

(**C. vulgaris* Linnaeus = *C vulgaris foetida* Vaillant). Oogonia consist of five sinistrally spiralled enveloping cells and five coronula cells that do not calcify. **Penn.–Recent.**

PALAEOCHARA Bell 1922

(**P. acadica*). Oogonia of six sinistrally spiralled units; coronula cells not preserved. **Penn.** (N. S.).

ACLISTOCHARA Peck 1937, emend 1941

(**A. bransoni*). Oogonia composed of five sinistrally spiralled units and five calcified coronula cells or, in the absence of the latter, indentations showing their former presence. **Penn.–Tert.**

A. moreyi Peck (**303**—6). Oogonia less than 0.5 mm in height, greatest diameter at or below mid-height; spiral ridges intercellular, making somewhat more than one complete turn around oogonium. **Penn., Perm.:** Mo., Kan.

A. latitruncata Peck (**303**—7, 8). Oogonia about 0.5 mm in diameter, subconoidal in shape, summit truncate or coronula cells forming a small pointed projection at center. **Morrison:** S. Dak., Mont., Colo., Wyo.

A. mundula Peck (**303**—9). Oogonia about 0.5 mm in diameter, vase-shaped, summit truncate, ridges cellular or intercellular; 11 to 12 spirals visible in lateral view. **L.** and **U. Cret.:** Mont., Wyo., Idaho.

A. sp. (**303**—4, 5). Oogonia less than 1 mm in diameter, ridges usually cellular, some specimens ornamented by rows of nodes running parallel to spiral units; coronula cells present on most specimens. **Eoc.:** Western Wyo., central Utah.

CLAVATOR Reid and Groves 1916, emend Harris 1939

(**C. reidi* Groves). Utricle with imperfect bilateral symmetry, units vertical or nearly vertical. **U. Jura** of England; **L. Cret.** of N. America.

C. harrisi Peck (**303**—14–16). Utricle well developed, composed of one fairly large deeply grooved unit, two opposed groups of units spreading fanwise from near base, and a fourth unit that originates as a single furrow near base, and divides, near meridian, into several units, which may again divide. **L. Cret.:** Tex., Mont., Wyo., Idaho.

ATOPOCHARA Peck 1938, emend 1941

(**A. trivolvis*). Regular five-spiralled oogonia inclosed in utricles with three-rayed symmetry, each ray consisting of three vertical units near base, five small units on or near equatorial plane, and four sinistrally spiralled units extending from equatorial plane to or near summit opening. **L. Cret.**

***A. trivolvis** Peck (**303**—13). **L. Cret.:** Okla., Tex., Mont., Wyo., Idaho.

PERIMNESTE Harris 1939

(**P. horrida*). Reproductive organs consisting of oogonia surrounded with leaf segments bearing antheridia; antheridial wall calcified. **U. Jura.** of England; **L. Cret.** of N. America.

P. corrugata Peck (**303**—10–12). Antheridia globular to subquadrate, divided into upper and lower hemispheres; wall thick, corrugated, penetrated by four openings; originating around polar openings are about 11 furrows that broaden distally, proceeding in a straight line or curving dextrally or sinistrally; furrows from opposite poles interfinger or meet along a sinuous ridge or against a horizontal furrow. **L. Cret.:** Tex., Mont., Wyo., Idaho.

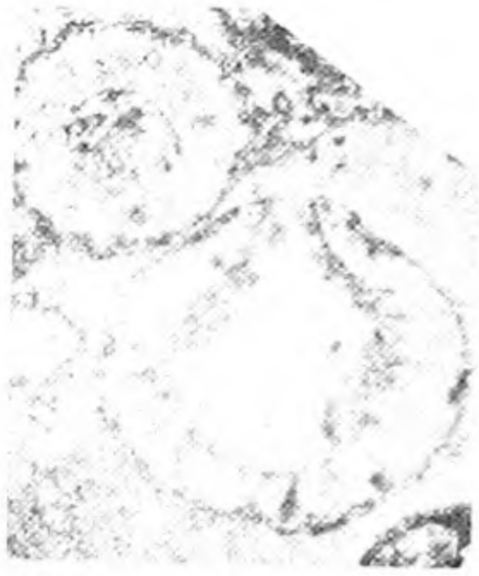
TROCHILISCUS Karpinsky 1906

(**T. ingricus*). Oogonia with 7 to 11 dextrally spiralled units; coronula cells calcified or not calcified. **Dev., L. Miss.**

T. octocostatus Peck (**303**—1, 2). Coronulate, diameter about 1 mm, ridges cellular or intercellular, eight in number, completing from a fourth to a half turn. **L. Miss.:** Mo.

SYCIDIUM Sandberger 1849

(**S. reticulatum*). Spherical bodies with variable number of meridional units expressed as grooves or



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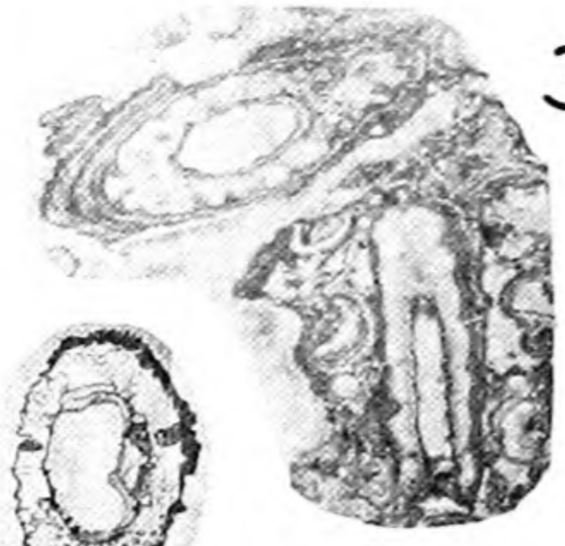

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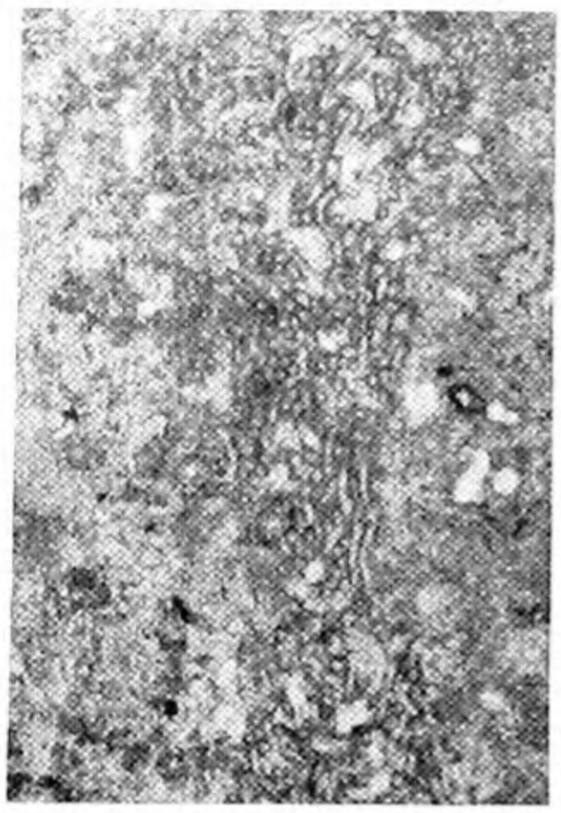

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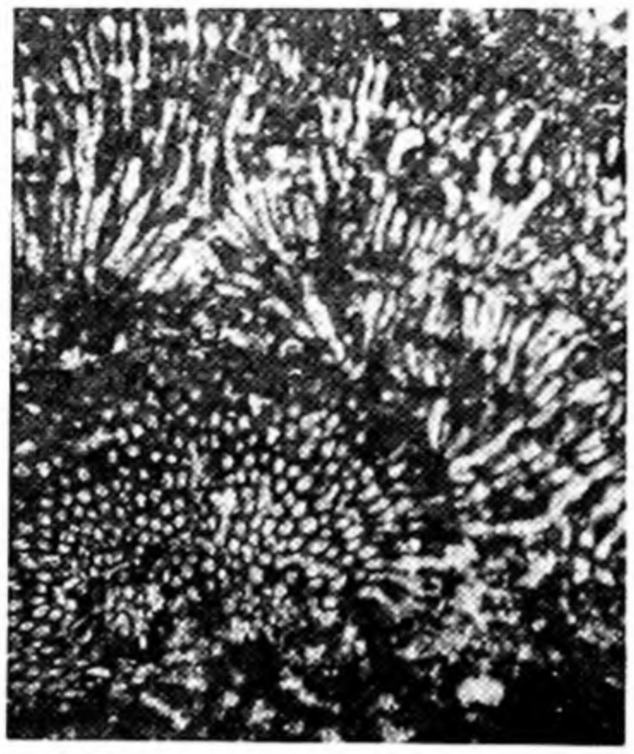

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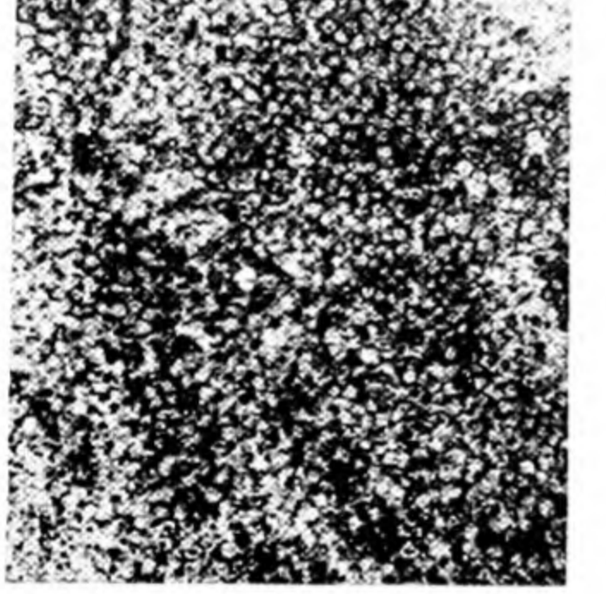

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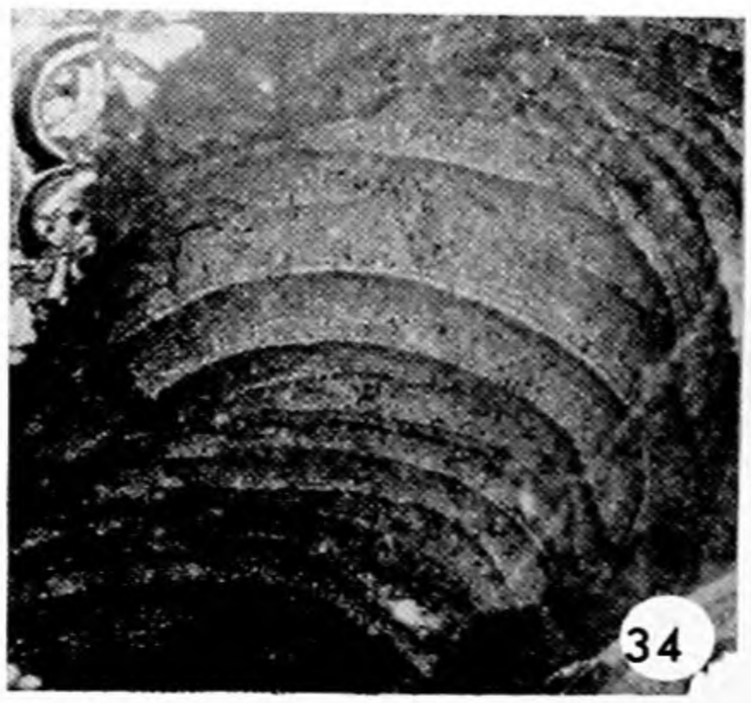

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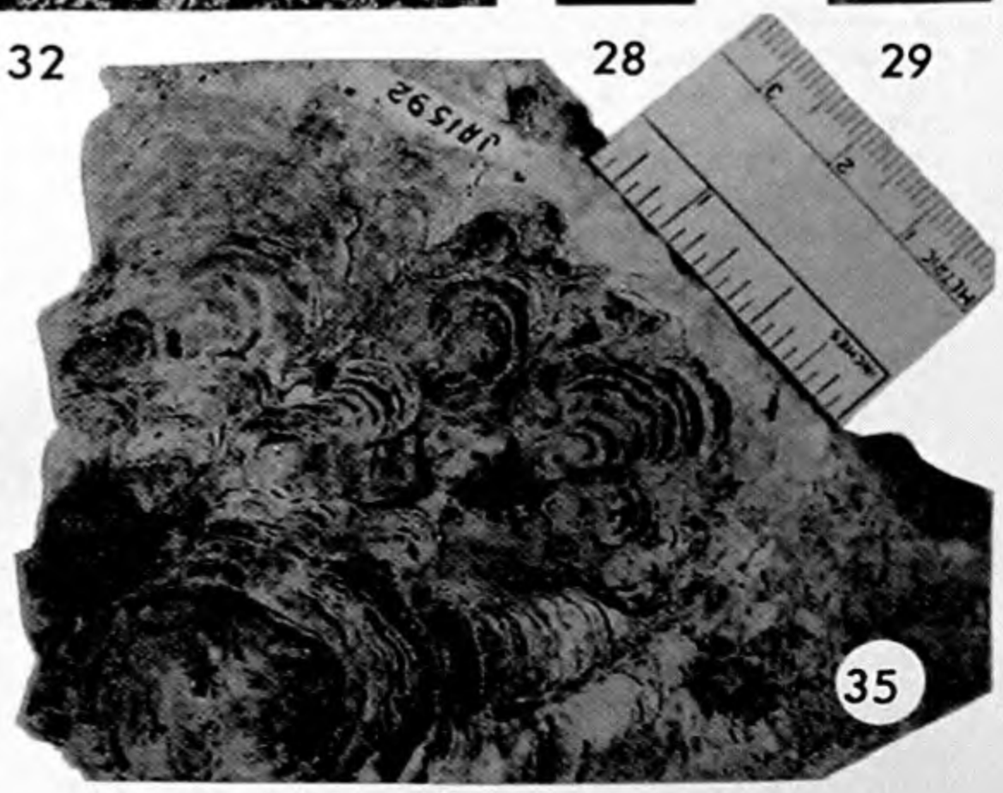

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Class	Family	Genus
Rhodophyta.	Corallineae.	Corallina Jania Ampheroa Arthrocardia
	Melobesieae.	*Solenopora Parachaetetes Pseudochaetetes *Archaeolithothamnium *Lithothamnium Mesophyllum Lithophyllum Melobesia Lithoporella
Chlorophyta.	Dasycladaceae.	Anthracoporella *Diplopora Griphoporella *Mizzia Macroporella Vermiporella Larraria *Gyroporella *Acicularia *Cymopolia Neomeris Clypeina
	Codiaceae.	*Mitcheldeania Hedstromia Ortonella Berovastria Polymorphocodium Ovulites
Cyanophyta (possibly Chlorophyta).	Porostromata.	*Girvanella Thamnidia Zonotrichites Epyrhyton?
Cyanophyta.	Spongiostroma.	Spongiostroma Stromatolith *Cryptozoon *Collenella *Collenia Gouldina

PLATE 302

[Figures are original by J. H. Johnson unless otherwise indicated; authors from whose works illustrations were taken are listed in the references under **Algae**.]

1, 2. Mizzia spp. (x25) [after Johnson], from **Perm.** of Guadalupe Mts., N. Mex. **1. M. velebitana.** Cross section above; longitudinal below. **2. M. yabei.** Longitudinal and oblique sections. **3–10. Diplopora annulata** (x4) [after Pia], from **Trias.** of Germany (Tyrol region). 3–5: Cross sections. 6–10: Longitudinal sections. **11–13. Acicularia schenckii** [after Morellet], from **Recent** of Bahamas. 11, 12: Sporangial spicules (x12). 13: Fragment of disk showing several connected spicules (x8). **14. Girvanella** sp. (x51), from **U. Camb.** of Eureka District, Nev. **15. Mitcheldeania gregaria** (x15), from **Miss.** near Bristol, England. Cross section of portion of colony showing characteristic branching. **16–19. Gyroporella maxima** (x4) [after Pia], from **Trias.** of Europe. 16, 17, and 19: Longitudinal sections. 18: Cross section. **20–23. Cympolia** sp. (x10) [after Morellet], from **Eocene** of Sussex, England. 20, 21: Longitudinal sections. 22, 23: External views. **24–29. Larvia davisi** (x10) [after Morellet], from **Eocene** of Sussex, England. 24–27: General external views, the first a worn fragment. 28: Longitudinal section. 29: Cross section view of lower surface. **30–32. Solenopora** spp. (x25). **30, 32. S. jurassica,** from **Juras.** of Orne, France. Cross and longitudinal sections of one of the fine textured species. **31. S. compacta,** from **M. Ord.** (Trenton) of Tenn. One of coarsely textured species. Section nearly perpendicular to "tubes" near base and about parallel at top. **33. Lithothamnium isthmi** (x90) [after Howe], from **Olig.** of Canal Zone. Longitudinal section. **34. Archeolithothamnium digitatum** (x35), from **Cret.** near Marseilles, France. Longitudinal section. **35. Collenella guadalupensis** (x0.8), from **Permian** of Guadalupe Mts. of N. Mex. This shows external structural appearance similar to *Collenia* and a number of other genera which range from **Pre-Camb.** to present.

Class	Family	Characteristic structures
Rhodophyta (red algae).	Corallineae. Melobesieae.	Rows of closely packed cells with polygonal cross-section. Cross partitions present though frequently very thin.
Chlorophyta (green algae).	Dasycladaceae (siphonous algae).	A central stalk, preserved as a tube or bulb, surrounded by tufts of leaves or leaf bases, preserved as knobs or brushlike protuberances.
	Codiaceae.	Small tubes loosely arranged so as to form segmented stems. Tubes round in cross-section and branching.
Cyanophyta (possibly chlorophyta).	Porostromata.	Small tubes so loosely arranged as not to compress each other. No cross partitions visible.
Cyanophyta (blue green algae).	Spongiostroma.	Cellular structure seldom preserved. The $CaCO_3$ is deposited as crusts on the outside of the colony or cell, or between the tissues, not in the cell wall. Classified on the basis of growth habit and form of the colony.

ridges; each unit subdivided transversely into pits and elevations. **Dev., L. Miss.**

S. foveatum Peck (**303**—3). Oogonia about 1 mm in diameter; pits alternating or in lateral alignment, divided into 18 vertical rows. **L. Miss.:** Mo.

CALCAREOUS ALGAE [1]

PREPARED BY J. HARLAN JOHNSON

Geologic Record. The fossil record of algae extends from the Pre-Cambrian to the present. Fossil algae are locally very abundant in the late Pre-Cambrian, the U. Cambrian, Ordovician, Mississippian, Permian, Triassic, Jurassic, U. Cretaceous, and the older Tertiary. Calcareous algae are very important as rock builders on modern "coral" reefs, and probably played just as important a role in the construction of ancient reefs.

Classification. The preceding table contains a simple classification of algae, with a brief statement of the characteristic structures in families:

A number of genera of fossil algae are grouped by families in the accompanying table. Only a few of these are illustrated here (pl **302**). They are indicated by an asterisk (*).

Geologic Use. Only the green and red algae give much promise for usefulness in correlation. The red coralline algae have received the most study and have been found to have definite correlative value in western Europe and the Mediterranean region. They have been studied slightly in the Caribbean area.

Studies of fossil algae suggest that practically all types of algae will give some information as to environmental conditions while the coralline red algae and the green siphonous algae have considerable possibilities as time indicators. For most areas and for most periods, however, we do not as yet have sufficient data on fossil algae to use them very much.

MISCELLANEOUS ALGAE

In addition to algae mentioned by Dr. Johnson in the preceding section, we describe and illustrate a few additional genera, chiefly from the early Paleozoic.

COLLENIA Walcott 1914

(**C. undosa*). Dome-shaped, massive, or turbinate, laminated bodies which grew with the arched surface

[1] Some of the more important references to fossil calcareous algae are: **Brown, A.,** On the structure and affinities of *Solenopora: G Mag* (4) 1: 145–151, 195–203, il, 1894. **Cloud, P. E., Jr.,** Notes on Stromatolites: *AJS* 240: 363–379, il, 1942. **Fenton, C. L.,** and **M. A.,** Algae and algal beds in the Belt Series of Glacier National Park: *JG* 39: 670–686, il, 1931; Belt Series of the North: Stratigraphy, Sedimentation, Paleontology: *GSA*, B 48: 1873–1970, il, 1937; Cambrian calcareous algae from Pennsylvania: *Am Mid Nat* 18: 435–441, il, 1937; Pre-Cambrian and Paleozoic algae: *GSA*, B 50: 89–126, il, 1939. **Garwood, E. J.,** Importance of rock-building algae: *G Mag* 10: 440–446, 490–498, 545–553, 1913; Important additions to knowledge of fossil calcareous algae since 1913: *GSL*, QJ 137: 74–100, 1931. **Gurich, G.,** Les Spongiaostromides du Viséen de la Province de Namur: *Mus roy Hist Nat Belg*, Mem 3: 1–55, il, 1906. **Howe, M. A.,** Contribution to the paleontology of the Canal Zone: *USNM*, B 103: 1–13, il, 1918; Geological importance of lime-secreting algae: *USGS*, PP 170: 57–65, 1932; also see *JP* 11: 369–370 for a list of other papers by the same author. **Johnson, J. H.,** Lime-secreting algae and algal limestones from Pennsylvanian of central Colorado: *GSA*, B 51: 571–596, il, 1940; Permian lime-secreting algae from Guadalupe Mountains, New Mexico: *GSA*, B 53: 195–226, il, 1942. **Johnson, J. H.,** and **Dorr, M. E.,** Permian algal genus *Mizzia: JP* 16: 63–77, il, 1942. **Lemoine, Mme. Paul,** Contribution à l'étude des Coralleneceae fossiles: *Soc Geol France*, B 17, 233–240, 240–256, 1917. **Morellet** and **Morellet,** Tertiary siphoneous algae in the W. K. Parker Collection. British Museum, 1939. **Pia, J.,** Die Siphoneae Verticillatae vom Karbon bis zur Kreide: *Zool-Botan Gesel Wien*, Abh 11: 1–163, il, 1920; Pflanzen als Gesteinsbildner, p 1–355, il, Berlin, 1926; Die wichtigstens Kalkalgen des Jungpalaozoikams und ihre geologische Bedeutung: *Comp Rend* XII *Congres Stratigraphic Carbonifere-Heerlen*, p 765–856, il, Maastricht, 1937. **Walcott, C. D.,** Pre-Cambrian Algonkian algal flora: *SMC* 64 (2): 77–156, il, 1914 (see also *GSA*, B 47: 609–620, il, 1936, for comments by **C. L.** and **M. A. Fenton**); Middle Cambrian algae: *SMC* 67 (5): 217–260, il, 1919.

uppermost; growth apparently by addition of external layers of varying thickness with interspaces that are likewise variable. **Pre-Camb.** (Mont. (Belt)).

***C. undosa** Walcott (**303**—33, 34). **Spokane:** Cordilleran region of N. America.

CRYPTOZOON Hall 1884

(**C. proliferum*). Calcareous bodies of variable size composed of irregular, concentric laminae of very unequal thickness traversed by minute canals which branch and anastomose irregularly. **Camb., Ord.** (widespread throughout N. America).

***C. proliferum** Hall (**303**—**37**). Compressed spherical cakes a foot or more in diameter. **U. Camb.:** N. Y. (Hoyt), Pa., Md., Va. (Conococheague).

C. proliferum fieldii Fenton and Fenton. **U. Camb.:** Pa. (Allentown).

C. undulatum Bassler (**303**—35, 36). **U. Camb.:** N. Y. (Hoyt), Pa. (Warrior, Allentown), Md. (Allentown).

DOLATOPHYCUS C. L. Fenton and M. A. Fenton 1937

(**D. expansus*). Colony prostrate, expanded, consisting of fine flexuous laminae which rise in gently convex domes separated by more abruptly convex, subangular or flattened furrows; basally, the convex domes are smaller than at the surface. **U. Camb.** (eastern N. America).

***D. expansus** F and F (**303**—28, 29). **U. Camb.:** Pa. (Allentown).

SOLENOPORA Dybowski 1877

(**S. spongioides*). Calcareous masses composed of radiating tubes with simple internal structure. **Ord.** (N. America; Europe).

S. compacta (Billings) (**302**—31; **303**—30–32). Colony subglobular, 25 to 50 mm in diameter; tubes vary from 0.1 to 0.5 mm in width, are irregular in form, and are sparingly tabulate. **M.** and **U. Ord.:** A common and widespread species in N. America, Estonia, and Russia.

BUTHOTREPHIS Hall 1847

(**B. antiquata*). Characterized by a central principal stem, more or less branched above; branches numerous. **Ord., Sil.** (N. America).

B. gracilis (Hall) (**303**—21). Vesicular stem and lateral branches of equal size; probably planktonic. **M. Sil.:** Reported from numerous localities in N. America.

HALYMENITES Sternberg 1833, emend Schimper 1869

(**Fucoides encoelioides* Brongniart (*de jure*); *H. brongniarti* Sternberg (*de facto*)). Frond coriaceous or membranaceous, smooth or fistulose; sporangia tuberculiform or punctiform, imbedded in the layers of the frond. **Mesozoic–Tert.** (N. America; Europe).

H. major Lesquereux (**303**—20). Surface of fronds marked by round, contiguous or separate tubercles; usually considered to be of algal origin, but recently Patterson (*JP* 16: 271–273, 1942) has suggested that the fossil is a borehole made by a marine animal. **U. Cret.** (especially characteristic of marine sandstones of Montanan and Lance; also present in U. Coloradoan): N. Dak. to Colo., Ark., Tex., Utah; **Eoc.:** Tex. (Carrizo).

MISCELLANEOUS OBJECTS OF PROBABLE ORGANIC ORIGIN [1]

Many sedimentary rocks contain markings which are of uncertain though probable organic origin. In some regions and at certain horizons, these features are useful as marker or index fossils, in spite of their uncertain origin. A number of them have been noticed and illustrated, as tracks, trails, borings, burrows, coprolitic masses and castings, and miscellaneous markings. Earlier paleontologists found convenient receptacles in the meaningless designations "worm trails" and "fucoids." More recent investigators, studying organisms in modern littoral and neritic environments, have discovered that many animals and some plants leave markings and other features of wide variety on sands and soft muds, and that some of these features are strikingly similar to those preserved in ancient rocks.

Some of the markings appear to have been made by walking invertebrates, such as crustaceans and arachnids. Others probably were excavated by animal parts, like the dragging telson of some arthropods. Still others probably were formed by some large wormlike animal, crawling over loose sand. Many of the markings, however, are difficult to associate with any known animals and it may well be that they are inorganic or that they were made by unknown extinct animals. There are also some which probably owe their origin to plants, directly or indirectly.

It has been common practice in recent years to assign an algal origin to almost any structure of concretionary nature, though it is almost certain that some of these structures are not organic at all.

We shall include here a few miscellaneous genera that have acquired some notoriety by repetition in

[1] **Burling, L. D.,** *Protichnites* and *Climactichnites:* a critical study of some Cambrian trails: *AJS* (4) 44: 387–398, il, 1917. **Dawson, J. W.,** On burrows and tracks of invertebrate animals in Paleozoic rocks, and other markings: *GSL*, QJ 46: 595–617, il, 1890. **Galloway, J. J.,** Nature of *Taonurus* and its use in estimating geologic time [Abst]: *GSA*, B 33: 199, 1922. **Ruedemann, R.,** *Oldhamia* (*Murchisonites*) *occidens* (Walcott): *N Y St Mus*, B 281: 47–50, il, 1929; *Oldhamia* and the Rensselaer grit problem: *N Y St Mus*, B 327: 5–12, il, 1942. **Sarle, C. J.,** *Arthrophycus* and *Daedalus* of burrow origin: *Rochester Ac Sc*, Pr 4: 203–210, il, 1906. **Walcott, C. D.,** See numerous papers on Cambrian faunas in *SMC* publications. **Woodworth, J. B.,** On the sedentary impression of the animal whose trail is known as *Climactichnites: N Y St Mus N H*, B 69: 959–966, 1902.

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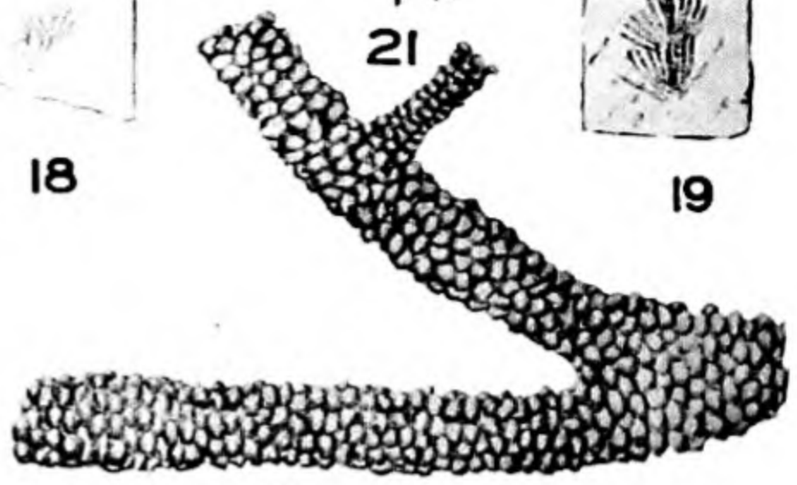
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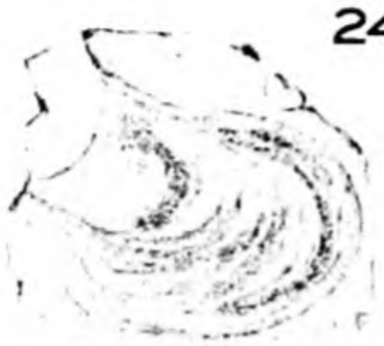
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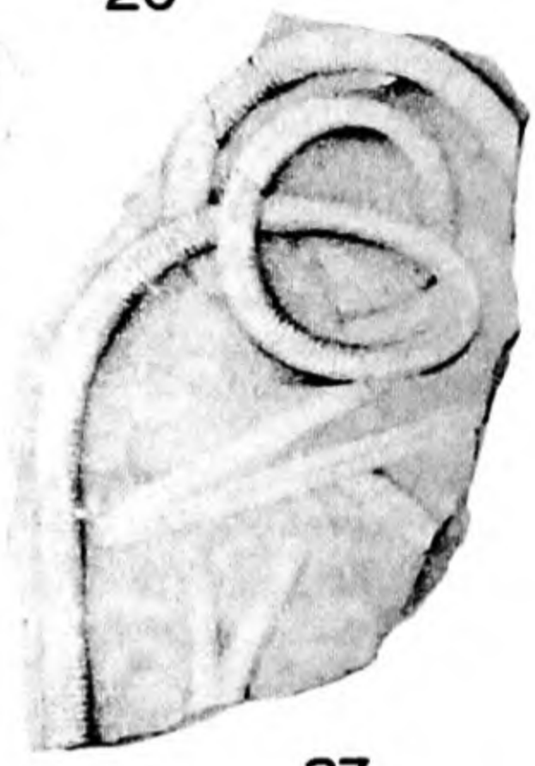
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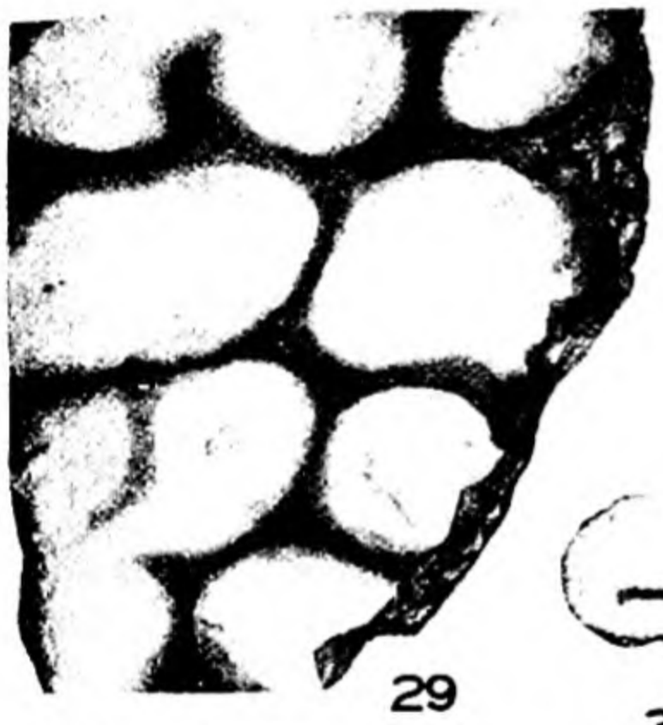
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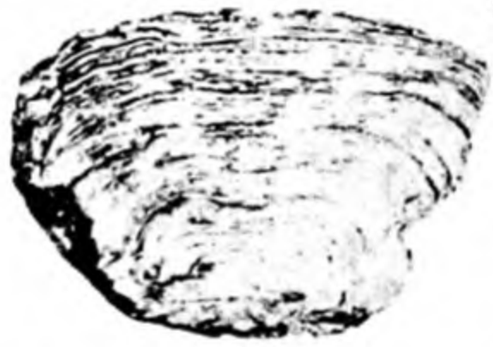
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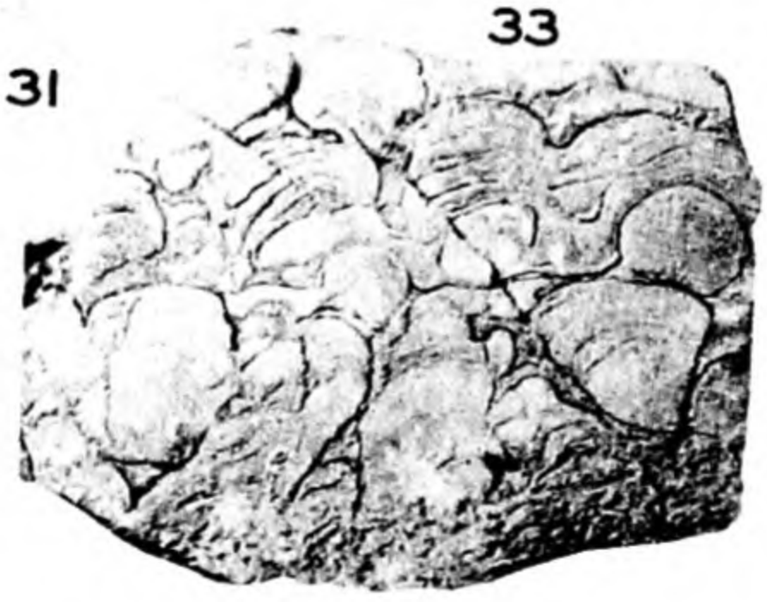
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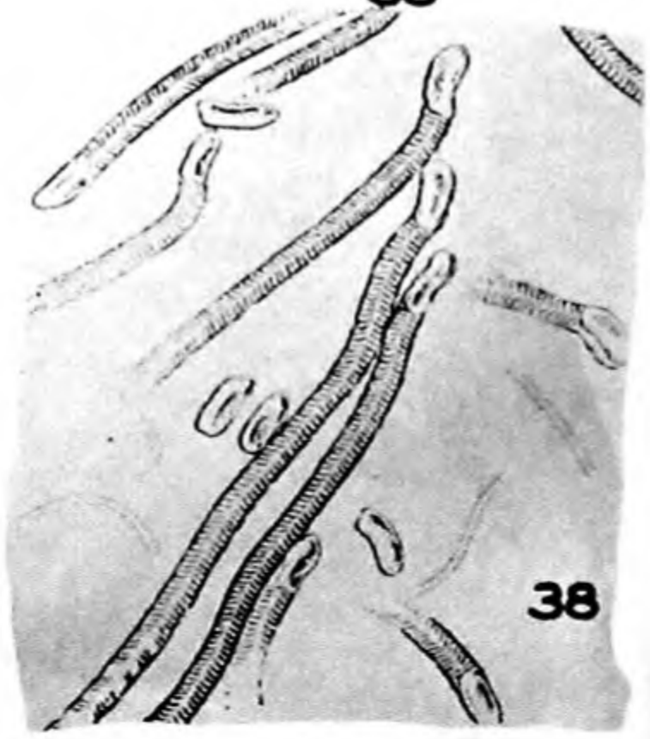
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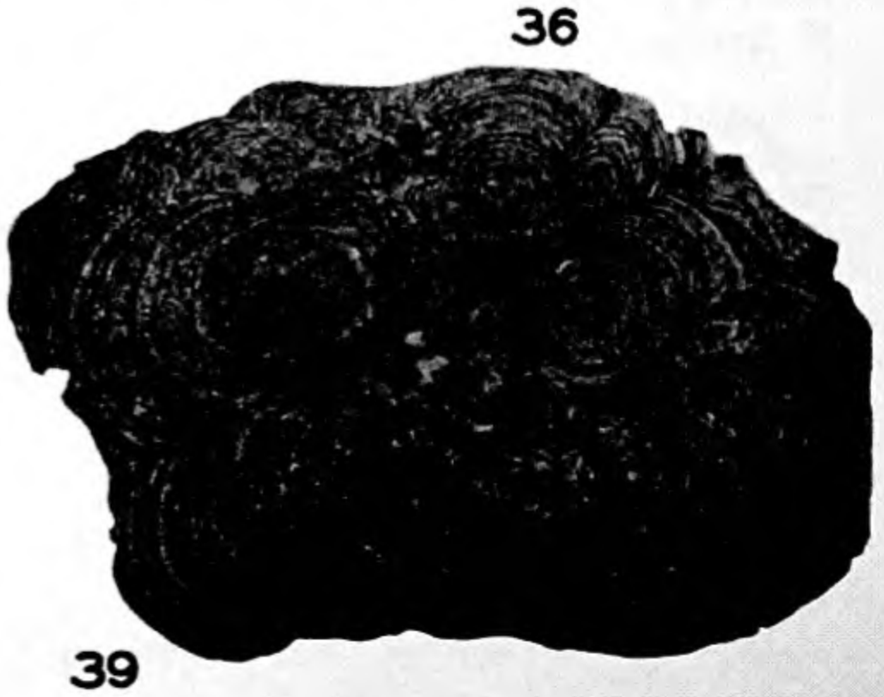
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faunal lists and textbooks. They may be of interest to the beginning student of Paleontology, at least as an example of one kind of "fossil." No attempt is made to classify them.

ARTHROPHYCUS Hall 1852

(**Fucoides harlani* Conrad). Simple or apparently branching, rounded or subangular ridges with median groove and closely set transverse grooves; originally described as a plant, it subsequently has been regarded as a worm burrow, but it may be the trail or burrow of some other animal. **L. Sil.** (eastern N. America).

A. alleghaniensis (Harlan) (= **A. harlani* (Conrad)) (**303**—26, 27). Numerous strong, rounded, elongated, and articulated branches which may unite near the base; these branches, with a diameter of 5 to 25 mm, are simple and approximately equidimensional throughout, and usually lie on bedding surfaces of sandstone layers. **Medinan:** Ont.; N. Y., Pa., and Md. (Tuscarora); Va. and Tenn. (Clinch).

CYCLOCRINITES Eichwald 1840, emend Stolley 1896

(= PASCEOLUS Billings 1857)

(**C. spaskii*). Globular or ovoidal bodies covered with an integument of small polygonal "plates," with one or more "apertures." **Ord., Sil.** (eastern N. America; Europe), **Dev.** (Europe).

C. globosus (Billings) (**303**—22). Type of genus *Pasceolus*. **Trenton:** Ont.; Ohio, Ky

OLDHAMIA Forbes 1848

(**O. radiata*). Possibly a plant; characterized by articulated structure, dichotomous branching and club-shaped appendages; considered a worm trail by Ruedemann (1942, 11). **Camb., Ord.** (N. America).

O. occidens (Walcott) (**303**—17–19). Characterized by a jointed, slightly flexuous stem with fan-shaped "fronds." **L. Camb.:** N. Y.

TAONURUS Fischer-Ooster 1858

(= SPIROPHYTON Hall 1863)

(**Fucoides cauda-galli* Vanuxem). Thin plates of ridged sandstone, nearly horizontal, U-shaped, suboval, or irregularly lobate, or more rarely forming low-inverted spirals, with the larger volutions downward; both faces of plates marked by U-shaped or otherwise curving, parallel lines; originally regarded as a plant and later interpreted as mechanical markings made by basally attached plants twisted by wind or water; also interpreted by some workers as packings of successive burrows. **Camb.–Tert.**

***T. caudagalli** (Vanuxem) (**303**—23, 24). In form resembling a rough spiral suggesting outline of a rooster's tail. **Dev.–Miss.** (Oriskany, Esopus): N. Y., Pa.; **L. Miss.:** Ohio, Ind.

T. velus (Vanuxem) (**303**—25). Broadly ear-shaped with lines of structure U-shaped. **Dev.** (Hamilton): N. Y., Pa.

CLIMACTICHNITES Logan 1860

(**C. wilsoni*). Trails marked by median and two marginal ridges, and by transverse broad groove or, in solid molds, by median groove and transverse broad ridges, the transverse elements converging obliquely to the longitudinal ones. **U. Camb.** (Que.; N. Y., Upper Mississippi Valley).

***C. wilsoni** Logan (**303**—37). Large, width measuring 12.5 to 16 cm, as measured from crest to crest of dividing ridge. **U. Camb.:** Que.; N. Y. (Potsdam), Wis. (Dresbach).

This trail may be that of an extinct crustacean, mollusk, or annelid worm, or possibly of some other extinct Cambrian organism.

PROTICHNITES Owen 1852

(**P. septem-notatus*). Trifid impressions believed by many paleontologists to have been made by a trilobite; the end of the trilobite's leg, with its three movable spines, is thought to have made the impression. **U. Camb.** (Que.; N. Y., Wis.).

P. logananus Marsh (**303**—38). Same range and distribution as genus.

PLATE 303

[Figures 1–16 are x15 and were furnished by R. E. Peck.]

1, 2. Trochiliscus octocostatus. Lateral and summit views showing cellular furrows and coronula cells. **3. Sycidium foveatum.** Lateral view. **4–9. Aclistochara** spp. **4, 5. Aclistochara** sp. Lateral view showing tubercles on spirals and summit view showing coronula cells in place. **6. A. moreyi.** Lateral view. **7, 8. A. latitruncata.** Lateral view and summit view showing coronula cells in place. **9. A. mundula.** Lateral view. **10–12. Perimneste corrugata.** Lateral view; end view; lateral view. **13. Atopochara trivolvis.** Lateral view. **14–16. Clavator harrisi.** Lateral views showing different units. **17–19. Oldhamia occidens** [N Y St Mus, B 281]. 17: A tuft enlarged (x1.7) to show branching and bases (*a*, club-shaped appendages; *b*, carbonaceous filament). 18: Three tufts as found arranged in the rock (x0.5). 19. Walcott's original figure (x0.5). **20. Halymenites major** [USGS Ter 7]. A typical specimen from sandstone (x0.5). **21. Buthotrephis gracilis** [Pal N Y 2]. A fragment with branches (x0.5). **22. Cyclocrinites globosus** (x0.5) [CGS, Pal Fos 1]. **23–25. Taonurus** spp [NYGS, G Rp 3rd Dist]. **23, 24. T. caudagalli** (x0.15). Much reduced figures showing two types of markings. **25. T. velus** (x0.25). Specimen, much reduced, showing characteristic ear shape of marking. **26, 27. Arthrophycus alleghaniensis** (x0.5) [Pal N Y 2]. A fragment showing base of large stem which diverges into numerous branches; a fragment of a branch somewhat spirally twisted and flattened. **28, 29. Dolatophycus expansus** [Am Mid Nat 18]. Upper surface of holotype (x0.25); vertical section of a paratype (x0.5). **30–32. Solenopora compacta** [Minn G S 3 (1)]. Vertical and transverse sections (x25) [after Nicholson]; a typical specimen (x0.5) **33, 34. Collenia undosa** [GSA, B 48]. Natural section of a colony (x0.25); natural section of a compound colony whose total width is about 1.3 m (50 in.) (x0.5). **35, 36. Cryptozoon undulatum** (x0.45) [Am Mid Nat 18]. Transverse section through a series of domes of several sizes; vertical section through hypotype showing internal structure. **37. Climactichnites wilsoni** [SMC 57 (9)]. A portion of a slab much reduced (x0.02), showing several trails. **38. Protichnites logananus** [SMC 57 (9)]. A slab 145 cm × 87.7 cm (4 ft 10 in. × 2 ft 11 in.), reduced to about x0.06, showing several trails. **39. Cryptozoon proliferum** (x0.5) [Md G S, Camb–Ord]. Upper side of a well preserved specimen, the original of which was 55 cm (22 in.) wide. The specimen shows several colonies (heads) unequally developed.

INDEX OF GENERA

[In this index are included also names of subgenera, families, orders, classes, and phyla. The numbers refer to page and plate-figures.]

A

Aatocrinus, 163
  mooresi, 163, 63—10
  mucrospinus, 163, 63—3
  patulus, 163, 63—4
  robustus, 163, 62—21; 63—11
Abrotocrinus, 159, 161
  cymosus, 159, 60—1
  unicus, 159, 59—15
Acadagnostus, 600
  acadicus, 600, 251—11, 12
Acantherpestes, 701
  major, 701, 294—17, 22
Acanthoceras, 591
  stephensoni, 591, 245—3, 4
Acanthocrinus, 185
  longispina, 185
  spinosus, 185, 72—13
Acanthocyclus, 85
Acanthodesia, 273
  oblongula, 273, 103—17
  savartii, 273, 103—18
  savartii bifoliata, 273, 103—18
Acanthodiscus, 587
  magnificus, 587, 243—8, 9
Acanthograptus, 67
  granti, 67, 20—24
  walkeri, 67
Acanthonema, 477
  holopiforme, 477
  newberryi, 477, 195—22–24
Acanthopecten, 403
  carboniferus, 403, 159—26, 27
  coloradoensis, 403, 159—25
Acanthopleura, scabra, 527
Acanthoscapha, 682
  navicula, 682, 286—44
  pentagonalis, 682, 286—42, 43
Acanthoscaphites, 591
  nodosus, 591, 246—3
  nodosus brevis, 591, 246—1, 2
  nodosus quadrangularis, 591, 246—4–6
Acanthosphaera, dodecaspinosa, 48, 14—28
Acanthotelson, 697
  stimpsoni, 697, 294—1–6
Acaste, 635
  downingiae, 635, 274—13
Acentrotremites, 133
Acervularia, 95, 99
  baltica, 101
Achatella, 635
  achates, 637, 273—17
Acheilops, 619
  dilatus, 619, 263—9–11
Acheilus, 619
  marcoui, 619, 263—8
Achistrum, 227
  nicholsoni, 227
Acicularia, 715
  schenckii, 302—11–13
Acidaspis, 651
Acila, 375
  decisa, 375, 146—11
  gettysburgensis, 377, 146—12
Acila, shumardi, 375, 146—10
Acleistoceras, 559
  hyatti, 559, 229—20, 21
Aclisina, grantonensis, 463
Aclistochara, 713
  bransoni, 713
  latitruncata, 713, 303—7, 8
  moreyi, 713, 303—6
  mundula, 713, 303—9
  sp., 713, 303—4, 5
Acodus, 239
  bicostatus, 239, 93—30, 31
  brevis, 239, 93—32, 33
  erectus, 239
Acontiodus, 239, 240
  latus, 239, 93—28, 29, 43
Acratia, 685
  tumida, 685, 288—14–16
  typica, 685, 288—17, 18
Acrochordiceras, 579
  hyatti, 579, 238—18–20
Acrocrinidae, 199
Acrocrinus, 199
  amphora, 199, 78—15
  armatus, 195, 76—10
  pirum, 199, 78—14
  shumardi, 199
Acroculia, 473
Acrogenia, 270
  prolifera, 270, 102—19, 20
Acrohelia, 121
  limonensis, 121
  singleyi, 121, 44—8, 9
  vicksburgensis, 121, 44—10, 11
Acrolichas, 637, 654
  cucullus, 637, 270—19–22
  cucullus ottawaensis, 637, 270—23, 24
Acrophyllum, 83, 99
  oneidaense, 99, 32—13
Acrospirifer, 323, 325
  gaspensis, 323, 123—9–11
  murchisoni, 325, 123—15, 16
  pinyonensis, 325, 123—14
Acrothele, 289
  burlingi, 289
  colleni, 289
  coriacea, 289, 108—15–17
Acrotreta, 289, 105—16, 17
  idahoensis, 289, 108—34–39
  microscopica, 289
  ophirensis, 289
  subconica, 289
Acrotretacea, 283, 287
Acteocina, 515
  canaliculata, 515, 212—14
  culcitella, 515, 212—16–18
  wetherelli, 515
Acteon, 515
  attenuatus, 515, 211—26, 27
  concinnus, 515
  linteus, 515, 211—30, 31
  ovoides, 515, 211—25
  traski, 515, 211—32
  vaughani, 515, 211—29

Actinoceras, 551, 555
beloitense, 551, 226—3
bigsbyi, 551, 226—1, 2
hearsti, 551
Actinocrinites, 193, 71—10
boonensis, 193, 77—12
expansus, 179
lowei, 193, 76—4
multiradiatus, 193, 76—3
rubra, 193, 76—2
simplex, 193
spinulosus, 193, 77—13
tenuisculptus, 193, 77—14
triacontadactylus, 193
verrucosus, 193, 76—1
Actinocrinitidae, 191
Actinocrinus, christyi, 197
evansii, 191
gilbertsoni, 191
indianaensis, 197
kentuckiensis, 191
konincki, 197
pentagonus, 193
proboscidialis, 191
pyriformis, 195
regalis, 193
tenuiradiatus, 127
umbrosus, 193
ventricosus, 193
Actinopterella, 383
radialis, 383, 149—9, 10
Actinopteria, 391
auriculata, 391, 152—15
boydi, 391, 152—19, 20
communis, 391, 152—16
decussata, 391, 152—18
muricata, 391, 152—21
textilis, 391, 152—17
textilis arenaria, 391
Actinoptychus, heliopelta, 301—36
Actinostroma, 59
clathratum, 59
expansum, 59, 18—7
tenuifilatum, 59, 18—4-6
Actinotrypa, 271
peculiaris, 271, 103—7
Acus, 511
curvilineata, 511
curvilineata calvertensis, 511, 210—21
curvilineata dalli, 511, 210—19
curvilineata whitfieldi, 511, 210—22, 23
curvilirata, 511, 210—20
Adelphoceras, meslerianum, 571
Adeona, 276
grisea, 276
heckeli, 276, 104—18
Adeonellopsis, umbilicata, 276, 104—18
Adinocrinus, 161
compactilis, 161, 60—23
nodosus, 161, 60—25; 62—4
pentagonus, 161, 60—24
Adrianites, 575
adamsi, 575, 236—11
elegans, 575
Aechmina, 665
bigeneris, 665, 280—60, 61
cuspidata, 665, 280—53
ionensis, 665, 280—54, 55
richmondensis, 665, 280—51, 52
spinosa, 665
Aenona, 429
eufaulensis, 429, 171—1, 2
Aequipecten, 403, 405
perplanus, 407
Aesiocrinus, 167
magnificus, 167, 56—32; 62—32
Agaricia, swinderniana, 109
Agaricocrinites, 195, 71—8
brevis, 195, 76—15
bullatus, 195, 76—14
planoconvexus, 195, 76—13
wortheni, 195, 76—22
Agaronia, alabamensis, 511, 210—13
Agasoma, kernianum, 500
Agassizocrinidae, 175
Agassizocrinus, 175
conicus, 175, 177, 61—7
gibbosus, 177, 61—5
laevis, 177, 61—8
ovalis, 177, 61—9
tarri, 177
Agathiceras, 575
frechi, 575, 236—12, 13
suessi, 575
Agelacrinites, 131
hamiltonensis, 131, 49—22
squamosus, 131
Agelacrinus, 131
cincinnatiensis, 129
kaskaskiensis, 131
pileus, 131
stellatus, 129
Agelacystis, 131
Ageladiscus, 131
Ageneracrinus, 175
subtumidus, 209
Aglaoglypta, 445
koeneni, 445, 179—19, 20
maera, 445, 179—16-18
Aglaspida, 705
Aglaspis, 705
barrandei, 705
spinifer, 705, 298—2, 3, 7
Agnostia, 599, 600
Agnostus, 600
acadicus, 600
cyclopyge, 601
fissus, 600
gibbus, 600
interstrictus, 600, 251—16, 17
montis, 600, 251—1, 2, 19
nobilis, 619
pisiformis, 600
pisiformis obesus, 600
punctuosus, 600
rugulosus, 600, 251—13, 14
tuberculatus, 675
Agoniatites, 565
vanuxemi, 565, 231—9, 10
Agraulos, 605, 617
quadrangularis, 605, 255—13, 14
saratogensis, 631
strenuus, 617
Aktinocyclina, 47
bainbridgensis, 47
Alabina, 497
cerithidioides, 497, 203—17
curta, 497, 203—18
Albertella, 605
helena, 605, 258—1-3
Alcimocrinus, 167
girtyi, 167, 61—15
Alcyonaria, 103, 105
Alecto, canadensis, 251
dichotoma, 250
Alectryonia, 395
carinata, 395, 153—21
falcata, 395, 154—10, 11
lugubris, 395, 154—4, 5
quadriplicata, 395, 153—22, 23
subovata, 395, 153—20
Algae, calcareous, 716

Alisocrinus, 199
laevis, 199, 74—2
Allagecrinidae, 147
Allagecrinus, 149, 52—4
americanus, 147
austinii, 149
bassleri, 149, 56—9
dignatus, 149, 56—10
strimplei, 149, 56—8
Allocatillocrinus, 149, 52—4
carpenteri, 149, 55—4
morrowensis, 149, 56—18
rotundus, 149, 56—19
Allocrinus, 200, 70—11
longidactylus, 200, 73—21
typus, 200, 73—18
Allomorphina, 41
trigona, 41
velascoensis, 41, 10—12
Allonema, 250
botelloides, 250
fusiforme, 250, 95—9
Alloprosallocrinus, 195
conicus, 195, 75—4
Allorhynchus, 311
heteropsis, 311, 118—66-68
Allorisma, 414
costatum, 414, 165—2
geinitzi, 414, 165—1
granosum, 414, 165—12
subcuneata, 414, 165—10, 11
sulcatum, 414
terminale, 414, 165—10, 11
Allumettoceras, 557
josephianum, 557, 228—14, 15
Alokistocare, 605
americanum, 605, 255—16
idahoense, 605, 255—9
labrosum, 607
Alpheus, nigro-spinatus, 298—10
Alsataspis, 637
bakeri, 637
evansi, 637, 274—1
Alsopocrinus, 158
Alveolites, 105
goldfussi, 105, 36—6-8
niagarensis, 105
squamosus, 105
suborbicularis, 105
undosus, 105, 36—9
Amaurellina, 481
moragai lajollaensis, 481, 197—30
Amauropsis, 481
alveata, 481, 197—30
bulbiformis, 481, 197—33, 34
Amblysiphonella, 56
prosseri, 56, 17—8, 9
Ambocoelia, 329
umbonata, 329, 126—21-26
Ambolodus, 237
triangularis, 237, 93—7, 8
Ambonychia, 381, 385, 387
amygdalina, 385, 149—22
bellistriata, 385, 149—29, 30
lamellosa, 387
radiata, 385
Ameura, 637
major, 637, 275—23, 24
sangamonensis, 637, 275—25-27
Ammobaculites, 15
taylorensis, 15, 1—12
Ammochilostoma, triloculina, 17
Ammodiscus, 15
regularis, 15, 1—9
semiconstrictus regularis, 15, 1—9
Ammonicrinus, 145
Ammonites, beudanti, 591
canaliculatus, 583
conradi, 589
cordatus, 585
dufrenoyi, 589
ehrlichi, 581
elimatus, 585
fimbriatus, 581
heterophyllus, 581
hystrix, 587
leopoldinus, 589
listeri, 573
lobatus, 595
loganianus, 587
mammillatum, 591
morikeanus, 587
neocomiensis, 587
nimbatus, 585
nodosus, 579
pictus costatus, 583
pierdenalis, 593
placenta, 595
planula, 585
radiatus, 587
reticulatus, 581
rhotomagensis, 591
richardsoni, 585
roissyanus, 589
sandlingensis, 581
spitiensis, 589
subbullatus, 579
swallovi, 591
tenuilobatus, 583
tenuistriatus, 587
texanus, 593
vespertinus, 593
woolgari, 593
Ammonoidea, 366, 528, 563
Amnigenia, 399
catskillensis, 399, 155—17
Amorphognathus, 237
ordovicica, 237
ramosa, 237, 93—5, 6
Ampelocrinidae, 167
Ampelocrinus, 167
Ampheristocrinidae, 154
Ampheristocrinus, 154, 54—29
typus, 154, 54—28
Ampheroa, 715
Amphicrinus, 179, 67—2
carbonarius, 179, 79—32
scoticus, 179
Amphicyrtoceras, 559
orcas, 559, 229—18, 19
pettiti, 559, 229—13, 14
Amphigenia, 363
curta, 363, 141—53-55
elongata, 363, 141—49-52
Amphilichas, 654
rhinoceras, 649
Amphineura, 366, 526
Amphion, canadensis, 651
Amphipora, 63
Amphipsalidocrinus, 154
Amphiscapha, 465
catilloides, 465, 188—23-25
muricatus, 465, 188—40 42
reedsi, 465, 188—26-28
subquadratus, 465, 188—29-31
subrugosus, 465, 188—34-39
Amphissites, 671, 673
carinatus, 671, 282—28-30
centronotus, 671, 282—32-35
dattonensis, 671, 282—36
girtyi, 671, 282—40-42

Amphissites, roundyi, 671, 282—37-39
rugosus, 671, 282—26, 27
subquadratus, 671, 282—31
Amphiura, 213
chiajii, 213
sanctaecrucis, 213, 81—17, 18
Amphoracrinidae, 191
Amphoracrinus, 191
americanus, 195
divergens, 191, 77—28
Amphoridea, 125
Amplexograptus, amplexicaulis, 73, 22—8-10
Amplexopora, 257, 258
cingulata, 258, 97—20-23
Amplexus, 87, 93
coralloides, 93
corrugatus, 93, 29—16, 18
hamiltoniae, 93, 29—9, 10
nevadensis, 93, 29—14, 15
shumardi, 93, 29—6-8
yandelli, 93, 29—11-13
Ampullina, 481
avellana, 481, 197—32
depressa, 481
mississippiensis, 481, 197—31
Ampullinopsis, mississippiensis, 481, 197—31
Ampyx, rostratus, 649
Amusium, 405
mortoni, 407, 163—1
Amygdalocystites, 125, 127
florealis, 125, 127, 47—9-11
Anamesocrinidae, 147
Anamesocrinus, 147, 52—1
lutheri, 147, 56—12
Anaptychus, 528
Anartiocrinus, 177
lyoni, 177
maxvillensis, 177, 61—11
Anascaphites, 589
Anasibrites, 579
kingianus, 579, 238—1-3
Anastomopora, 264
perundata, 264, 100—8
Anastrophia, 303, 106—6, 11
internascens, 303, 114—53-55
verneuili, 303, 114—48-52
Anastrophina, 469
Anatimya, 414
anteradiata, 415, 165—20
Anatinacea, 413
Anatomites, brockensis 581, 239—9-11
Anchiopsis, 637
anchiops, 637, 274—20-22
Anchura, 497, 499
abrupta, 497, 203—22
facilformis, 497 203—26
rostrata, 497, 203—23
sublaevis, 497
Ancilla, 511
Ancillaria, altilis, 511
staminea, 511
Ancillopsis, 511
subglobosa, 511, 210—10
Ancistrorhyncha, 307
costata, 307, 117—30-33
Ancistrosyrinx, 513
Ancistrum, 227, 90—17-25
brownwoodensis, 227, 90—22, 23
ludwigi, 227, 90—21
Ancyloceras, douvillei 589
jenneyi, 593
Ancyrocrinus, spinosus, 209, 79—30
Ancyrodella, 244, 245
nodosa, 244
sp., 244, 94—42, 43
Ancyrognathus, 244
Ancyrognathus, symmetrica, 244, 94—27, 28
Andrarina, 605
ouangondiana, 605, 276—26
tenera, 605, 259—12, 13; 276—25
Anematina, 471
marshalli, 471, 192—16, 17
minutissima, 471, 192—20, 21
proutana, 471, 192—18, 19
Anglicornus, 559
anneliesae, 559, 229—15
Angulodus 240
demissus, 240, 93—58
Angulogerina, 37
byramensis, 37, 8—21
Angyomphalus, 453
Anisocrinus, 181, 66—4
greenei, 181, 54—8
interradiatus, 181
oswegoensis, 181, 54—7
Anisomyon, 519
borealis, 519, 212—37-39
centralis, 519
haydeni, 519, 212—32
meekii, 519
patelliformis, 519, 212—28-31
sexsulcatus, 519, 212—35, 36
subovatus, 519, 212—33, 34
Anisopyge, 637
perannulata, 637, 275—19-22
Annelida, 228
Annulata, 228
Annuliconcha, interlineatus, 401, 159—18, 19
Anodonta, 368
Anolotichia, 253
impolita, 253, 96—18
ponderosa, 253
Anomalina, 43
punctulata, 43
rubignosa, 43, 11—10
Anomalocaris, 655
canadensis, 655, 277—6
gigantea, 655, 277—7
Anomalocrinidae, 151
Anomalocrinus, 151, 52—8
incurvus, 151, 53—26
Anomalodesmacea, 366, 413
Anomalofusus, 507
substriatus, 507, 208—17
Anomalorthis, 298
nevadensis, 298
oklahomensis, 298
utahensis, 298, 112—4-8
Anomia, 409
argentaria, 409, 163—18, 19
biloba, 355
ephippium, 409
gryphorhynchus, 409, 163—24
micronema, 409, 163—17
reticularis, 317
retusa, 365
sandalinum, 99
tellinoides, 409, 163—15, 16
Anomiacea, 409
Anomites, exporrectus, 321
punctatus, 350
resupinatus, 357
scabriculus, 350
semireticulatus, 349
striatus, 325
Anomocytheridea, 689
floridana, 689, 290—23-25
Anomoeoneis, follis, 301—17
Anomphalus, 471
rotulus, 471, 193—25, 26
umbilicatus, 473, 193—27-29

Anoplia, 347
nucleata, 347, 135—17–20
Anoria, 605
tontoensis, 605, 258—18
Anostylostroma, 59
hamiltonense, 59, 18—8, 9
Antagmus, 605
typicalis, 605, 253—6
Antalis, 521
cooperi, 523, 214—22, 23
Antediplodon, dockumensis, 399, 158—3
Anthocyrtium, doronicum, 48, 14—21
Anthozoa, 58, 79
Anthracoceras, 571
discus, 571
missouriense, 571, 234—20, 21
Anthracomartus, 709
trilobitus, 709, 300—3, 4
volkelianus, 709
Anthracomya, 399
elongata, 399, 155—8, 9
Anthraconectes, 707
mazonensis, 707, 299—8, 9
Anthracoporella, 715
Anthrapalaemon, 697
gracilis, 697, 294—25, 26
grossarti, 697
Antiguastrea, 119
cellulosa, 119, 44—1, 2
Antirotella, 471
Antispirifer, 325
harroldi, 325, 123—17–19
Aorocrinus, 195
immaturus, 195, 76—9
parvus, 195, 76—11
Aparchites, 664
arrectus, 665
canadensis, 664, 280—17–19
minutissimus, 664, 280—21
whiteavesi, 664, 280—20
Apatognathus, 240
varians, 240, 93—59–61
Aphelaspis, 619
depressus, 619, 263—35, 36
hamblenensis, 619, 263—37
walcotti, 619, 263—31
Apheoorthis, 295, 106—5
emmonsi, 295
lineocosta, 295, 110—34–37
melita, 295
Aphera, 515
waltonensis, 515, 211—36
Aphetoceras, 541
americanum, 541
farnsworthi, 541, 221—9
Aphrodina, tippana, 427, 170—17, 18
Apical, glyptus, 209, 79—24
regularis, 209, 79—25
urna, 209, 79—21
Apioceras, olla, 559
oviforme, 559
Apiocrinidae, 205
Apiocrinus, 205
tehuantepec, 205, 79—7
Apiocystites, imago, 128
Aplacophora, 366, 527
Apographiocrinidae, 157
Apographiocrinus, 158, 62—28
exculptus, 158, 58—8
typicalis, 158, 56—21; 62—22
Apollocrinus, 52—14
Aporita, 129
Aporrhais, 499
nuptialis, 499, 204—10, 11
prolabiata, 499, 204—9
quadrifidus. 499
Apterinella, 29
grahamensis, 29, 5—16, 17
Apterygota, 703
Aptychus, 528
Arabellites, 229, 231
bipennis, 231
comis, 229, 91—6
cristatus, 229, 91—8
cuspidatus, 229, 91—16
elegans, 229, 91—7
gibbosus, 229, 91—17
giganteus, 229, 91—18
hamatus, 229, 91—1
lunatus, 229, 91—5
magnificus, 229, 91—11
marcellusensis, 229, 91—21
ovalis, 91—2
oviformis, 229, 91—14, 15
plenidens, 229, 91—20
politus, 229, 91—3
priscus, 229, 91—19
rectidens, 229, 91—12, 13
scutellatus, 229, 91—4
similis, 229, 91—9
similis arcuatus, 229, 91—10
Arachnida, 599, 703
Arachnocrinus, 153
bulbosus, 153, 57—10, 21
extensus, 153, 57—29
ignotus, 153, 57—14
Arachnophyllum, 101
mamillare, 101, 34—5
pentagonum, 101, 34—2–4
striatum, 101, 34—1
Araeonema, 471
virgatum, 471, 192—32, 33
Araeosoma, bicolor, 89—36
Arapahoia, 619
prolixa, 619, 263—19, 20
ransomei, 619, 263—15, 16
typa, 619, 263—17, 18
Arbacia, 221
improcera, 221, 84—1–3
Arca, 367, 368, 379, 381
antiquata, 381
barbata, 381
costata, 415
cuculloides, 383, 148—7
glycymeris, 383
marylandica, 383, 148—9
micronema, 383, 148—5, 6
morsei, 383, 148—8
nucleus, 375
rostrata, 377
trilineata, 383, 148—10
Arcacea, 379
Arcestes, 581
galeati, 581
shastaensis, 581, 239—7, 8
Archaeocidaris, 217
Archaeocrinidae, 183
Archaeocrinus, 183, 70—6
desideratus, 183, 73—14
Archaeocyathus, 56
Archaeogastropoda, 366, 439
Archaeolithothamnium, 715
Archaeorthis, 295
costellata, 295
elongata, 295, 110—43–46
glomerata, 295
Archaeoscyphia, 51, 56
minganensis, 51, 15—5, 6
Archaeostraca, 599, 655
incertae sedis, 659
Archeocyathus, 51, 56
atlanticus, 56, 17—6, 7

Archeocyathus, profundus, 57
rensselaericus, 56, 17—14, 15
Archeolithothamnium, digitatum, 302—34
Archiannelida, 228
Archichaetopoda, 228
Archimedes, 249, 264
communis, 264, 100—5
intermedius, 264
laxus, 264, 100—6
proutanus, 264
sublaxus, 264, 100—7
swallovanus, 264
terebriformis, 264, 100—4
wortheni, 264, 100—3
Archinacella, 469
deformata, 469, 191—16, 17
powersi, 469, 191—1, 2
Architectonica, 489
alveata, 489, 200—13, 14
cognata, 491, 200—15
euprepes, 491, 200—16–18
krebsii lampra, 491, 200—19–22
nobilis quadriseriata, 491, 200—23–25
Arcopagia, texana, 425, 169—20
Arctica, 417
occidentalis, 417, 166—18
ovata, 417, 166—16, 17
Arctinurus, 637
boltoni, 637, 271—1, 8, 10, 19
nereus, 637, 271—9
occidentalis, 637, 271—17, 18
Arenicola, 234
didyma, 234
Arenicolites, 234
woodi, 234, 92—29, 30
Argilloecia, 687
cylindrica, 687
faba, 687, 288—39–41
Argyrotheca, 365
johnsoni, 365, 143—38–40
Arion, ceticephalus, 605
Arionellus, convexus, 621
oweni, 629
texanus, 635
Aristerella, 411
nitidula, 411, 164—10, 11
Armenoceras, 551, 553, 555
hearsti, 551, 226—7
Armonia, 605
elongata, 605, 255—21
Arniotites, 581
vancouverensis, 581, 239—3
Arroges, evansi, 497
Arthroacantha, 197
ithacensis, 197
punctobrachiata, 197, 78—9
splendens, 197, 78—10
Arthrocardia, 715
Arthroclema, 265
armatum, 265, 101—2, 3
billingsi, 265, 101—1
pulchellum, 265
Arthrolycosa, 709
antiqua, 709, 300—18
Arthrophycus, 719
alleghaniensis, 719, 303—26, 27
harlani, 719, 303—26, 27
Arthropoda, 599
Arthropora, 269
bifurcata, 269, 101—29
shafferi, 269
simplex, 269, 101—30, 31
Arthrostylus, 265
obliquus, 265, 100—15, 16
Articulata, 205, 281, 283, 293
Artinskia, 569
Artinskia, huecoensis, 569, 232—14, 15
whortoni, 569, 232—16, 17
Asaphiscus, 607, 611
capella, 611
elongatus, 605
gregarius, 607
wheeleri, 607, 258—9
Asaphocrinus, 181
bassleri, 181, 54—9
ornatus, 181, 68—2; 69—17
Asaphus, armadillo, 649
aspectans, 641
barrandei, 637
canalis, 647
extans, 639
gemmuliferus, 651
housmanni, 649
selenourus, 649
seticornis, 654
Ascetocrinus, 159
rusticellus, 159, 55—14
scoparius, 159, 55—17
Ascoceras, 537
anticostiensis, 537
bohemicum, 537
canadense, 535
croneisi, 537, 218—9
Ascodictyon, 250
stellatum, 250, 95—2
Aspidites, superbus, 577
Aspidodiadema, tonsum, 89—37
Aspidopora, 257
areolata, 257
elegantula, 257, 97—16, 17
Astacus, 701
chenoderma, 701, 296—11–13
subterraneus, 699
Astartacea, 417
Astarte, 417
lurida, 417
packardi, 417, 166—27, 28
trapezoidalis, 417, 166—25, 26
Astartella, 417
newberryi, 417, 166—14
vera, 417, 166—15
Asteractinella, audax, 56, 16—9, 10
Asterias, ophiura, 213
Asterigerina, 39
carinata, 39
subacuta, 39, 10—5
Asterocrinus, capitalis, 199
Asterocyclina, 47
georgiana, 47, 12—10
mariannensis, 47, 12—18
Asteroidea, 123, 211
Asterorbis, 45
rooki, 45, 12—1, 2
Astraea, cellulosa, 119
dendroidea, 117
guettardi, 119
heliopora, 115
marylandica, 121
myriophthalma, 115
numisma, 115
porosa, 103
Astraeospongia, 55, 57
meniscus, 57, 17—16, 17
Astreopora, 115
antiguensis, 115, 42—21, 22
Astrhelia, 119
palmata, 119, 44—19
Astrocoenia, 115
decaturensis, 115, 42—15
guadalupae, 115
maloniana, 115, 42—13, 14
whitneyi, 115, 42—16

Astrodaspis, 223
antiselli, 223
brewerianus, 223, 85—6, 7
spatiosus, 223, 85—8, 9
tumidus, 223, 85—4, 5
Astylospongia, 53
praemorsa, 53, 15—14, 15
Atactoporella, 257
typicalis, 257, 97—3-5
Atactotoechus, 257
typicus, 257, 258
winchelli, 258
Atelestocrinus, 155
Athecocyclina, 47
cookei, 47, 12—12, 13
Athleta, leioderma, 508
Athlocrinus, 163
clypeiformis, 163, 63—12
placidus, 163, 62—1; 63—13
Athyris, 283, 333, 335
angelica, 333, 127—48-51
angelicoides, 333, 127—46, 47
congesta, 331
cora, 333, 127—38
headi, 317
lamellosa, 333, 127—44, 45
royssyii, 333
spiriferoides, 333, 127—39-43
Atira, 480
ornatissima, 480, 197—10
Atopochara, 713
trivolvis, 713, 303—13
Atractites, 595
philippii, 595, 250—1, 2
solidus, 595, 249—13
Atremata, 283, 284
Atrypa, 282, 283, 317, 319, 106—13
arata, 305
bellula, 319, 121—10-12
bisulcata, 317
congregata, 311
cuboides, 313
devoniana, 319, 121—16-18
elegans, 319, 121—8, 9
elongata, 363
exigua, 317
extans, 307
flabellites, 319
hemiplicata, 303
hirsuta, 361
hystrix, 319, 121—13
imbricata, 317
independensis, 319, 120—69-71
laevis, 331
linguifera, 303
medialis, 311
modesta, 317
nevadana, 319, 121—6, 7
nitida, 331
peculiaris, 311
prunum, 319
reticularis, 1, 319, 121—1-3, 14, 15
spinosa, 319, 121—4, 5
transversa, 445
unisulcata, 333
Atrypacea, 283
Atrypella, 319
shrocki, 319, 120—62, 63
Atrypina, 319
disparilis, 319, 121—29
imbricata, 319, 121—30-32
Aturia, 549
alabamensis, 549, 225—10, 11
vanuxemi, 549, 225—12, 13
Aturoidea, 549
paucifex, 549, 225—14
Atyphocrinus, 149
Aucella, 393
piochii ovata, 395, 153—15, 16
Aulacella, 353
infera, 353, 138—24-27
Aulacera, 61, 63
undulata, 63, 19—16, 19, 20
Aulacodiscus, rogersii, 301—40
Aulacophyllum, 93, 101
bilaterale, 101, 34—6
sulcatum, 101, 34—7, 8
Aulacosphinctes, 587
wilfridi, 587, 242—14, 15
Aulacoteuthis, 597
impressus, 597, 250—9, 10
Auliscus, californicus, 301—5
Aulocaulis, 113
annectens, 113, 40—12
expansus, 113, 40—13
Aulocrinus, 171
agassizi, 171, 61—14
Aulopea, 473
Aulopora, 1, 111, 113, 115
anna, 113, 40—9
conferta, 111, 40—5
elleri, 113, 40—6
expansa, 113
michiganensis, 111, 40—14
modulata, 113, 40—7, 8
serpens, 111
umbellifera, 113
Aulosteges, 349, 135—31-33
medlicottianus, 349
tibeticus, 349
variabilis, 349
wolfcampensis, 349
Auluroidea, 123, 213
Aurinia, 508
dubia, 508
mutabilis, 508, 209—10, 11
Auriptygma, virgatum, 479
Austinella, 298
kankakensis, 298, 112—1-3
whitfieldi, 298
Avellana, 515
avellana, 515
bullata, 515, 212—1, 2
Avicula, 391
antiqua, 389
dispar, 385
erecta, 383
fragilis, 385
mosquensis, 393
munsteri, 391
orbiculata, 403
pinnaeformis, 387
Aviculopecten, 401, 403
cancellatus, 401, 159—17
cleon, 401, 159—16
girtyi, 401, 159—23
interlineatus, 401, 159—18, 19
limaformis, 405
occidentalis, 401, 159—21, 22
planoradiatus, 401
providencesis, 401, 159—20
vanvleeti, 401, 159—24
Aviculopinna, 387
americana, 387, 150—10
peracuta, 387, 150—8, 9
Avitelmessus, 699
grapsoideus, 699, 296—1-4
Avonia, 349, 105—4
oklahomensis, 349, 135—46-48
Axonolipa, 64
Axonophora, 64
Axophyllum, 89

Axophyllum, expansum, 89
rude, 89, 25—20-22
Axosmilia, 122
craginiana, 122, 46—9

B

Bactrites, 565
aciculum, 565, 231—1, 2
arkonensis, 565, 231—3
ellipticus, 565
gracilior, 565, 231—4
subconicus, 565
Bactrognathus, 243
angularis, 243, 94—15, 16
excavata, 243, 94—13, 14
hamata, 243
Bactropora, 267
simplex, 267, 101—18, 19
Baculites, 583
anceps, 583
aquilaensis, 583, 240—1, 2
asper, 583
codyensis, 583, 240—10, 11
codyensis obesus, 583
compressus, 583, 240—3-5
gracilis, 583, 240—9
ovatus, 583, 240—6-8
ovatus haresi, 583
Bailiaspis, 607
prominens, 607, 253—16
venusta, 607, 253—19
Bailiella, 607
baileyi, 607, 253—10-12; 276—21
venulosa, 607, 276—20
Bairdia, 683
aequa, 683, 287—29, 30
alexandrina, 683, 287—37
attenuata, 683, 287—27, 28
bosquetiana, 683
cestriensis, 683, 287—24-26
citriformis, 683, 287—18-20
curta, 683
glenrosensis, 683, 287—21, 22
magnacurta, 683, 287—15, 16
oklahomaensis, 683, 287—17
reussiana, 683, 287—31-34
sinuosa, 683, 287—35, 36
subdeltoidea, 683, 287—37
suborbiculata, 683, 287—38
summacuminata, 683, 287—23
Bairdiolites, 685
crescentis, 685, 288—8, 9
fornicatus, 685, 288—19, 20
Bairdocypris, morrisonensis, 683, 287—57-59
Bairdoppilata, 683
martyni, 683
Bakewellia, 389
gouldii, 385
parva, 389, 150—19
Balanocrinus, 207
haitiensis, 207, 79—4
mexicanus, 207, 79—5
subteres, 207
Balanophyllia, 122
calyculus, 122
desmophyllum, 122, 46—12, 13
elaborata, 122, 46—14-16
irrorata, 122, 46—10, 11
variabilis, 122, 46—17-19
Balantoides, 673
quadrilobatus, 673, 282—48
Balanus, 695
concavus, 695, 293—14-31
vulgaris, 695
Barbarofusus, 505
barbarensis, 505, 208—1
Barbatia, 381
cuculloides, 383, 148—7
marylandica, 383, 148—9
micronema, 383, 148—5, 6
morsei, 383, 148—8
Barrandella, 303
fornicata, 303, 114—56-58
Barrandeoceras, 543
natator, 543, 221—13
Barroisella, 285
campbelli, 285, 107—29-32
subspatulata, 285, 107—29-32
Barychilina, 687
punctostriata, 687, 288—35-38
Barycrinidae, 154
Barycrinus, 154
princeps, 154, 57—26
protuberans, 154, 57—15
wachsmuthi, 154, 57—18
Baryphyllum, 85
verneuilianum, 85, 23—34-37
Basiliella, 637
barrandei, 637, 267—38
Bassleratia, 669
typa, 669, 281—54-57
Bathmopterus, 467
Bathyurellus, 637
abruptus, 637
brevispinus, 639, 267—32, 33
Bathyuriscus, 607
anteros, 615
dawsoni, 613
formosus, 607, 258—11
rossensis, 617
rotundatus, 607, 258—12
Bathyurus, 639
armatus, 631
capax, 629
conicus, 647
extans, 639, 267—37
haydeni, 607
parvulus, 607
quadratus, 649
spiniger, 639, 267—36
texanus, 635
Batocrinidae, 195
Batocrinus, 195, 71—6
calvini, 195
icosadactylus, 195, 75—1
macbridei, 195, 75—7
subaequalis, 195, 75—5
wachsmuthi, 195, 75—6
Batostoma, 259
fertile, 259, 99—1, 2
irrasum, 259
Batostomella, 258
granulifera, 258, 98—4-6
spinulosa, 258, 98—1-3
Battus, rex, 600
tuberculatus, 675
Baylea, 453
capertoni, 453, 184—10-12
knighti, 453, 184—6, 7
perhumerosa, 453, 184—8,9
subconstricta, 453, 184—1-5
Beachia, 363, 364
suessana, 364, 142—10-14
Beatricea, 61, 63
gracilis, 63
nodulosa, 63, 19—17, 18
undulata, 63
Beatricidae, 61
Beckwithia, 705
typa, 705, 298—1
Beecherella, 682
carinata, 682, 286—56

Beecherella, navicula, 682
Belemnite, puzosianus, 595
Belemnitella, 597
  americana, 597, 250—13–18
  mucronatus, 597
Belemnites, absolutiformis, 597
  brunsvicensis, 597
  excentralis, 595
  mucronatus, 597
Belemnoidea, 366
Bellerophon, 443, 445
  antiquatus, 441
  bilobatus, 441
  crassus, 443, 178—21, 22
  curvilineatus, 443
  koeneni, 445
  lindsleyi, 445
  megalostoma, 441
  montfortianus, 445
  newberryi, 477
  patulus, 441
  pelops, 443, 178—15–17
  percarinatus, 445
  sublaevis, 443, 178—18–20
  sulcatinus, 441
  troosti, 443, 178—12–14
  urei, 445
  vasulites, 443
Bellerophontidae, 435
Bellinurus, danae, 707
Bellornatia, 669
  tricollis, 669, 281—51, 52
Belodus, 240
  compressus, 240, 93—56
  gracilis, 240, 93—51, 52
  sp., 240, 93—55, 57
Beloitoceras, 557
  pandion, 557, 228—16–18
Beloptera, sepioidea, 597
Belosepia, 597
  ungula, 597, 250—19–21
Bembexia, 457
  adjutor, 457, 184—29
  capillaria, 457, 184—30
  sulcomarginata, 457, 184—25, 26
  trilix, 457, 184—27, 28
Beraunia, 475
Berenicea, 250
  minnesotensis, 250, 95—16, 17
  prominens, 250
Bergeronia, elegans, 617, 253—9
Berovastria, 715
Beudanticeras, 591
  breweri, 591, 245—1, 2
Beyrichia, 675
  chambersi, 667
  ciliata, 669
  cincinnatiensis, 665
  contracta, 675, 283—27, 28
  decora, 677
  fastigiata, 679
  mandula, 665
  moodeyi, 675, 283—23–26
  quadrilirata, 667
  sagitta, 675, 283—29–31
  tonolowayensis, 675, 283—33
  tuberculata, 675, 283—32
  wilckensiana, 675
Beyrichiella, gregaria, 679
Beyrichiopsis, 685
  fimbriata, 685
  thori, 685, 288—10–13
Beyrichona, 657
  papilio, 657, 278—7
  tinea, 657, 278—6
Bicaspis, 607
Bicaspis, typica, 607, 259—17, 18
Bickmorites, 543
  bickmoreanum, 543, 222—7–9
Bigenerina, 17
  nodosaria, 17
  wintoni, 17, 2—3
Billingsaria, 105
  parva, 105, 35—16–20
Billingsastraea, 97
  billingsi, 97
  billingsi nevadensis, 97, 32—10
  verneuili, 97, 31—7
Billingsella, 293, 295, 105—9
  coloradoensis, 293
  perfecta, 293, 110—12–17
Billingsia, 439
  saratogensis, 439
Billingsites, 535
  canadensis, 537, 218—18
Bilobites, 355
  bilobus, 355, 138—50, 51
  varicus, 355, 138—49
Biloculina, sphaera, 29
Bimuria, 335, 105—6
  superba, 335, 128—29–33
Bisatoceras, 573
  primum, 573, 235—3, 4
Bittium, 495
  boiplex, 495, 203—13
  cerithidioide, 497
  cossmanni, 495, 203—16
  eschrichtii, 495, 203—14
  permutabile, 495, 203—15
Blainia, 607
  elongatus, 605
  gregarius, 607, 259—19
Blastoidea, 123, 133
Blothrocrinidae, 158
Blothrocrinus, 158
  jesupi, 158, 58—20
  spartarius, 158, 58—4
  swallovi, 158, 58—11
Blothrocyathus, 117
  harrisi, 117, 43—22–25
Blothrophyllum, 97
  decorticatum, 97, 31—5, 6
Blountia, 619
  mimula, 619, 263—3, 4
Blumenbachium, meniscus, 57
Boesites, 569
  texanus, 569, 233—6, 7
Bolaspis, 607
  labrosum, 607, 255—25, 26
Bolis, 503
  lisboa, 503, 207—15, 16
Bolivina, 35, 37
  draco, 33
  incrassata, 35, 8—17
  plicata, 35
Bolivinita, 33
  planata, 33, 8—7
Bolivinoides, 33
  decorata, 33, 8—6
Bollia, 667
  americana zygocornis, 667, 281—29–31
  bicollina, 667
  burgeneri, 667, 281—32
  regularis, 667, 281—27, 28
  subaequata, 667, 281—24–26
  ungula, 667, 281—33–35, 67–69
Bonnemaia, 677
  celsa, 677, 284—11, 12
  rudis, 677, 284—13, 14
Bonnia, 607
  fieldensis, 607, 256—13, 14
  parvula, 607, 256—5

Bonnia, senecta, 607, 256—11, 12
Bonniella, 607
desiderata, 607, 256—6, 7
tumida, 609, 256—19
virginica, 609, 256—17
Borelis, princeps, 23
Borestes, 455
pagoda, 455, 183—34
wrighti, 455
Botryllopora, 255
socialis, 255, 96—25, 26
Botryocrinidae, 155
Botryocrinus, 154, 155, 52—9
americanus, 155, 57—1₁
crassus, 155, 57—23
nycteus, 155, 57—9, 22
polyxo, 155, 54—22
ramosissimus, 155
Bourgueticrinidae, 205
Brachial, acutus, 209, 79—19
pustullosus, 209
simus, 209, 79—11
Brachiopoda, 277
Brachyaspis, 639, 654
notans, 639, 268—22
Brachycycloceras, 539
normale, 539, 220—5
Brachycythere, 688
interrasilis, 688, 289—22
ledaforma, 688, 289—19–21
russelli, 688, 289—23–27
sphenoides, 688, 289—16–18
Brachydontes, multilinigera, 413, 164—16
Brachymetopus, 639
armatus, 639, 275—13–15
lodiensis, 639, 275—28
spinosus, 639, 275—16–18
strzeleckii, 639
Brachyprion, 339
leda, 339, 129—10
Brachyspirifer, 323
audaculus, 323, 123—12, 13
Brachythyris, 327
subcardiformis, 327, 125—9–11
Bradfordoceras, 551
consortale, 553, 226—11
transversum, 551, 226—10
Bradoria, 655, 657
robusta, 655, 278—1
scrutator, 655, 278—2–4
Bradorina, 655
Bradorona, 655
Brahmacrinus, 200
elongatus, 200, 77—18
ponderosus, 200
Branchiopoda, 599, 659
Brassicephalus, 621
pulchellus, 621, 263—21–23
Breviarca, 379
exigua, 379, 146—52, 53
haddonfieldensis, 379, 146—54, 55
Brevicoceras, 559
casteri, 559, 230—1
Brevispirifer, 323
gregarius, 323, 122—22–26
lucasensis, 323, 122—17–19
Briscoia, 621, 629
sinclairensis, 621, 262—29–31
Bronteopsis, 639
gregaria, 639, 267—23
scotica, 639
Bronteus, 653
Brooksina, 305
alaskensis, 305, 115—31–33
Bruclarkia, 503
gravida, 503, 206—17
Bryantodina, 243
typicalis, 243, 94—25
Bryantodus, 243
mundus, 243, 94—21
typicus, 243
Brychiocrinus, 52—14
Bryograptus, 69
kjerulfi, 69
lapworthi, 69, 21—1
Bryozoa, 247
Bucanella, 441
brevilineata, 441, 176—17
cordiformis, 441, 176—9–14
nana, 441, 176—18–20
trilobata, 441, 176—15, 16
Bucania, 441
bidorsata, 441
costalis, 441, 177—5–8
sulcatina, 441, 177—12, 13
Bucanopsis, 443
carinifera, 443, 178—24, 25
leda, 443, 178—23
modesta, 443, 179—6–8
tenuilineata, 443, 179—3–5
textilis, 443, 179—1, 2
Buccinum, 503
echinophora, 500
mississippiensis, 505
plectrum, 503, 207—5
sagenum, 501
strigilatum, 511
subulatum, 511
tranquebaricum, 503
undatum, 503
Buccitriton, 501
texanum, 501, 206—6
Buchia, 393
crassa, 395, 153—13, 14
piochii, 395, 153—12
terebratuloides, 395, 153—15, 16
Buchiola, 373
retrostriata, 373
speciosa, 373, 145—17, 18
Bulimella, 479
bulimiformis, 479
canaliculata, 477
Bulimina, 35
marginata, 35
obtusa, 35, 8—15
Buliminella, 35
carseyae, 35, 8—13
elegantissima, 35
Bulimorpha, 479
bulimiformis, 479, 196—5, 6
Bulla, 517
cylindracea, 515
fontinalis, 519
macrostoma, 517
vendryesiana, 517, 212—24
Bullaria, 517
Bullia, striata, 517
Bullopora, 32
laevis, 32, 7—6
rostrata, 32
Bullus, 517, 639, 649
ampulla, 517
Bumastus, 639
barriensis, 639
globosus, 639, 269—1, 2
insignis, 639, 269—10–12
ioxus, 639, 269—13, 14
milleri, 639, 269—3–6
niagarensis, 639, 269—7–9
Burnetia, 621
extensa, 621, 263—24
urania, 621, 263—25, 26

Bursacrinus, 159
Buskopora, 255
dentata, 255, 96—24
Busycon, 500, 501, 503, 507
caricum, 501
contrarium, 501, 206—19
cretaceum, 501, 206—15, 16
fusiforme, 501, 206—12, 13
maximum, 501, 206—20
obrapum, 501
perversum, 503
pyriforme, 501
pyrum, 501
rapum, 501
tritone, 501, 206—14
tuberculatum, 501, 206—18
Buthotrephis, 717
antiquata, 717
gracilis, 717, 303—21
Buxtonia, 350
peruviana, 350, 136—21
semicircularis, 350, 136—20
Bynumia, 621
eumus, 621, 263—34
robsonensis, 621, 263—32, 33
Byssonychia, 385, 387
intermedia, 385, 149—25, 26
radiata, 385, 149—23, 24, 27, 28
Bythocypris, 683
clorensis, 683, 287—44, 45
cylindrica, 683, 287—46–49
favulosa, 682
gibsonensis, 683, 287—64–66
goodlandensis, 683, 287—42, 43
indianensis, 683, 287—60
morrisonensis, 683, 287—57–59
pediformis, 683, 287—54–56
reniformis, 683
rotundus, 683, 287—62, 63
subaequata, 683, 287—50–53
tomlinsoni, 683, 287—61
truncata, 683, 287—39–41
Bythopora, 258
fruticosa 258
herricki, 258, 98—10–13
Bythotrypa, 253

C

Cacabocrinus, troosti, 201
Cactocrinus, 191, 193, 71—11
arnoldi, 191, 77—4
glans, 193, 77—10
imperator, 191, 76—8
multibrachiatus, 191, 77—2
proboscidialis, 191, 77—3
Cadulus, 523
abruptus, 523, 214—29
depressicollis, 523
obnutus, 523, 214—27, 28
ovulum, 523
thallus, 523, 214—30
turgidus, 523, 214—26
Caecum, 491
mexicanum, 491, 200—26, 27
patuxentium, 491, 200—28
Calamopora, hemispherica, 107
Calapoecia, 109
anticostiensis, 109
canadensis, 38—10
canadensis anticostiensis, 109, 38—11–15
Calceocrinidae, 145
Calceocrinus, 145
bassleri, 145, 55—15
halli, 145
Calceola, 99
heteroclita, 359
Calceola, tennesseensis, 99, 32—17, 18
Calcispongiae, 49, 56
Calcivertella, 29
adherens, 29, 5—13
Calicantharus, fortis, 503, 207—14
Callavia, 609
bröggeri, 609, 253—17
Callianassa, 699
mortoni, 699, 295—6-16
oregonensis, 699, 295—2–5
Callinectes, 699
sapidus, 699, 295—17–19
Calliocrinus, 201
beachleri, 201, 75—18
Calliops, 639
callicephala, 639, 273—20–23
Calliostoma, 480
canaliculatum, 480, 197—3
costatum, 480
philanthropus, 480, 197—2
Callipleura, 311
nobilis, 311, 118—69, 70
Callistochiton, 527
palmulatus mirabilis, 527, 216—9–14
Callocystites, 125, 128, 48—1–3
canadensis, 128, 48—3
jewetti, 128, 48—1, 2
Callograptus, 65
elegans, 65
staufferi, 65, 20—4, 5
Callonema, 469
Callopora, elegantula, 261
punctata, 259
Calvinella, 621
ozarkensis, 621, 261—15, 16
spiniger, 621, 261—13, 14
Calymene, 2, 641
anchiops, 637
blumenbachi, 641
caractaci, 645
celebra, 641, 272—6, 7
concinna, 651
downingiae, 635
niagarensis, 1, 641
platys, 641, 272—8–10
Calyptaulax, 641
glabella, 641, 273—24–26
Calyptraea, 487
aperta, 487, 199—38
centralis, 487, 199—32–34
diegoana, 487, 199—37
mamillaris, 487, 199—35, 36
Calyptraphorus, 499
jacksoni, 500, 204—5, 6
trinodiferus, 500, 204—7, 8
velatus, 499, 205—1–3
velatus compressus, 499
velatus nodovelatus, 205—1–3
Camaraspis, 621
convexa, 621, 260—12–14
Camarocladia, 56
dichotoma, 56, 17—1–3
rugosa, 56
Camarocrinus, ulrichi, 209, 79—34
Camarospira, 333
eucharis, 333, 127—28–31
Camarotoechia, 281, 309, 311, 315, 118—50
congregata, 311, 118—50–53
contracta, 311, 118—54–56
endlichi, 313
mutata, 311, 118—62–65
sappho, 311, 118—57–61
Cambrocyathus, 57
profundus, 57, 17—22, 23
Camerata, 183
Camerella, 303

Camerella, plicata, 303, 114—39–43
varians, 303
volborthi, 303, 114—36–38
Camerina, 33
laevigata, 33
matleyi, 33, 7—10–12
Cameroceras, 535
tenuiseptum, 535, 218—7, 8
trentonensis, 535
Camerophoria, 315
Campages, 105—11
Campeloma, 487
crassula, 487
multistriatum, 487, 199—22
vetulum, 487, 199—20, 21
Campophyllum, torquium, 91
Camptocrinus, 199
multicirrus, 199, 78—13
myelodactylus, 199
Camptonectes, 405
bellistriatus, 405, 160—16
pertenuistriatus, 405
platesea, 405, 161—4
Campylorthis, 297, 106—17
deflecta, 297, 111—36–41
magna, 297
Canadocystis, 125
barrandi, 125, 47—5, 6
emmonsi, 125, 47—3, 4
Cancellaria, 514, 515
alternata, 514, 211—20
conradiana, 514, 211—22
crawfordiana, 514, 211—24
gracilioides, 514, 211—23
lunata, 514, 211—21
tessellata, 515
Cancer, 699, 701
astacus, 701
attenarius, 701, 297—1
fissus, 701, 297—16
leachii, 701
pagurus, 699
punctulatus, 701
subterraneus, 699
Cancris, 39
sagra, 39, 10—8
Candorbulina, 41
universa, 41, 11—2, 3
Caneyella, 391
richardsoni, 391, 152—13, 14
Caninia, 91
cornucopiae, 91
juddi dawsoni, 91, 28—1–3
sulcata, 101
torquia, 91, 28—4–6
Cannartidium, 48, 14—25
Cannartiscus, amphicylindricus, 48, 14—20
Cantharus, 503
fortis, 503, 207—14
globularis, 503
Capiluna, 480
Caprina, 421
adversa, 421
occidentalis, 421, 168—11, 12
Carabocrinidae, 151, 153
Carabocrinus, 151, 153, 52—19
radiatus, 151, 153, 53—5
vancortlandti, 153, 53—6
Carboprimitia, 679
depressa, 679, 285—1–4
Carcinocrinus, 159
Carcinophyllum, 89
Cardiacea, 423
Cardioceras, 585
cordiforme, 585, 242—1, 2
distans, 585, 242—3–5
Cardiodella, 237
tumida, 239, 93—17, 18
Cardiodus, 237
tumidus, 237
Cardiopsis, 371
radiata, 371, 145—10
Carditacea, 419
Cardium, 368, 423, 425
cooperi, 425, 169—17
coosense, 425, 169—12, 13
corbis, 425
costatum, 423
dumosum, 425, 169—7, 8
elegantulum, 415
eufaulense, 425, 169—9, 10
hillanum, 425
line, 425
linteum, 425, 169—17
pauperculum, 423, 169—5
speciosum, 423, 169—6
spillmani, 425, 169—11
stultorum, 431
tenuistriatum, 425, 169—2–4
whitei, 423, 169—6
Caricella, 508
pyruloides, 508, 209—8
Carinaropsis, 445
carinata, 445, 180—1, 2
cymbula, 445, 180—3–5
Cariniferella, 353
tioga, 353, 138—34–38
Caritodens, demissa, 383, 148—16
Carnarvonia, 655
venosa, 655, 277—5
Carneyella, 131
nicklesi, 131, 49—12
Carpocrinus, 193, 71—4
laurelianus, 193, 75—13
Carposphaera, equalis, 48, 14—29
Caryocaris, 657
curvilata, 657, 279—3, 4
oklahomensis, 657, 279—1, 2
wrightii, 657
Caryocrinites, 125, 127, 47—22, 23
ornatus, 127, 47—22, 23
Caryocrinus, 127
Caryocystites, cylindricus, 125
Caryophyllia, cenomana, 121
cornicula, 91
extinctorium, 122
gigantea, 93
Cassidula, alveata, 501
Cassidulina, 41
cretacea, 41, 10—9
laevigata, 41
Cassidulus, 215, 223, 225
caribaearum, 223
gouldii, 225, 86—7–9
subquadratus, 225
Cassinoceras, 535
explanator, 535, 218—17
Cassiope, 491
branneri, 491, 201—5
Catactocrinus, 157
Catazyga, 317
headi, 317, 120—60, 61
Catillocrinus, 149, 52—4
bradleyi, 149
carpenteri, 149
tennesseeae, 149, 55—2
wachsmuthi, 149, 55—1
Catinella, 475
Catozone, 459
Cavaria, dumosa, 251
Cavellina, 685
glandella, 685, 288—28, 29

Cavellina, lata, 685, 288—23
nebrascensis, 685, 288—33, 34
parallela, 685, 288—30, 31
pulchella, 685, 288—32
Cavolina, 517
natans, 517
ventricosa, 517, 213—25-27
Cavusgnathus, 245
alta, 245
cristata, 245, 94—75-78
Cedaria, 621
minor, 621, 264—1, 2
prolifica, 621, 264—3-7
woosteri, 621, 264—8-10
Cellaria, cereoides, 275
Cellepora, descostilsii, 276
Cenosphaera, porosissima, 48, 14—26
Centrechinoida, 219
Centroceras, 545
marcellense, 545, 223—1
Centrocrinus, tennesseensis, 181
Centrocyrtoceras, 543
percinctum, 543, 222—11, 12
subannulatum, 543, 222—3
Centrognathodus, sinuosus, 240, 93—48
Centrognathus, 240
Centronella, 363
glansfagea, 363, 141—56, 57
impressa, 363, 141—58-61
Centropleura, 609
vermontensis, 609, 254—16
Centrotarphyceras, 541
seelyi, 541, 221—8
Cephalopoda, 366, 527
Ceramophylla, 253
frondosa, 253, 96—15, 16
Ceramopora, 253
alternata, 253
imbricata, 253, 96—12-14
Ceramoporella, 253
distincta, 253, 96—7
inclusa, 253, 96—5, 6
Ceratiocarina, 657
Ceratiocaris, 657
acuminata, 657, 278—17, 18
solenoides, 657
Ceratites, 579
blakei, 579
carbonarius, 569
humboldtensis, 579, 238—11-14
idrianus, 579
russelli, 579, 238—15-17
Ceratobulimina, 39
cretacea, 39, 10—6
Ceratocephala, 641
goniata, 641, 271—14, 15
Ceratolichas, 641
dracon, 641, 270—25, 27
gryps, 641, 270—28, 29
Ceratopea, 437, 447
capuliformis, 447, 181—11-13
keithi, 447, 181—5-10
tennesseensis, 447, 181—14-16
Ceratopora, 111, 113
jacksoni, 113, 40—15-17
Ceratopsis, 667
chambersi, 667, 281—48-50
oculifera, 669, 281—46, 47
Ceraunocochlis, 477
fulminula, 477, 196—1, 2
harrodsburgensis, 477, 196—3, 4
Ceraurinus, 641
icarus, 641, 272—15
marginatus, 641
Ceraurus, 641
pleurexanthemus, 641, 272—14
Cercidocrinidae, 159
Cercidocrinus, 159, 52—20
bursaeformis, 159, 59—10
infrequens, 159, 60—20
Ceriopora, constellata, 259
Cerithium, 497
adansonii, 497
bosquense, 497, 203—29
mesal, 495
Cestocrinus, 154
Chaenomya, 373
leavenworthensis, 373, 145—1, 2
Chaetetes, 103
cylindraceus, 103
milleporaceus, 103, 35—12-15
quadratus, 258
radians, 103
undulatus, 259
Chaetopleura, 526
apiculata, 527, 216—22-26
Chaetopoda, 228, 229
Chama, dosin, 427
Chamacea, 421
Chancelloria, 55
aurora, 55
eros, 55, 16—12, 13
Chancia, 609
ebdome, 609, 255—2, 3
Chara, 713
vulgaris, 713
vulgaris foetida, 713
Characeae, 712
Charactoceras, 561
baeri, 563, 230—15
Charientocrinus, 157
Chariocephalus, 621, 623
whitfieldi, 621, 264—11-13
wichitaensis, 621, 264—14, 15
Charophyta, 712, 716
Cheilostomata, 249, 261, 271
Cheirocrinus, chrysalis, 145
clarus, 145
dactylus, 145
Cheirodata, traquairii, 227
Cheirurus, 641
exsul, 641
niagarensis, 641, 272—13
welleri, 641, 272—11, 12
Chesterella, 679
exuta, 679, 285—14, 15
fissurata, 679
Chilobolbina, 675
billingsi, 675, 283—45
Chilotrypa, 255
hispida, 255, 96—19, 20
ostiolata, 255, 96—27-29
Chione, 427
latilirata, 427, 173—7-9
securis, 427, 170—10; 172—19
Chirognathidae, 237
Chirognathus, 237
alternata, 237, 93—12
duodactyla, 237
Chiton, 527
californicus, 527
canadensis, 526
carbonarius, 527, 216—27-34
eocenensis, 527, 216—15, 16
hindsii, 527
longicymba, 527
peruvianus, 526
pulchellus, 527
textilis, 527
tuberculatus, 527
wrightianus, 695
Chlamys, 403

Chlamys, choctavensis, 407, 161—17, 18
complexicosta, 405, 161—5
fucanus, 407, 161—21, 22
greggi, 407
johnsoni, 407, 161—14
nebrascensis, 405, 161—7, 8
wahtubbeanus, 407
Choia, 51
Chonetella, artiensis, 347
Chonetes, 281, 345, 347
arcuatus, 347
aurora, 345, 134—10
coronatus, 345, 347, 134—12–15
emmetensis, 347
fischeri, 347
geinitzianus, 347
granulifer, 347, 134—24–26
jerseyensis, 345, 134—27
macrostriatus, 345, 134—16
mesolobus, 347
novascoticus, 345, 134—8, 9
oklahomensis, 345, 134—17–20
reversa, 347
scitulus, 345, 134—11
shumardianus, 345, 134—28, 29
syrtalis, 345, 134—21–23
variolata, 345
Chonetina, 347
flemingi, 347, 135—11, 12
Chonopectus, 347
fischeri, 347, 135—15, 16
Chonophyllum, 97, 99, 101
magnificum, 101, 33—19–21
Chonostegites, 113
clappi, 113, 115, 41—18, 19
Chonostrophia, 347
complanata, 347, 135—9, 10
Choristothyris, 365
plicata, 365, 143—35–37
Chraspedops, 705
modesta, 705, 298—4, 8, 9
Christiania, 337
subquadrata, 339, 129—1–7
Cibicides, 43
martinezensis, 43, 11—12
refulgens, 43
Cibolocrinus, 181, 66—8
banioni, 183, 56—29
punctatus, 183, 56—13
tumidus, 183, 56—15
turbinatus, 175
typus, 181, 183, 56—16
Cidaris, 219
californicus, 219, 83—5–7
dilleri, 219, 83—4
koenigi, 219
papillata, 219
pustulosa, 221
splendens, 219, 83—12, 13
urii, 217
Cidaroida, 219
Ciderites, imperialis, 219
scutiger, 219
tribuloides, 219
Cimitaria, 414
angulata, 414, 165—19
recurva, 414, 165—17, 18
Cimomia, 549
subrecta, 551, 225—6
Cincinnatidiscus, 129
stellatus, 129, 49—17, 18
Cinulia, concinna, 515
Cirripedia, 599, 693
Cirropsis, 469
Cladochonus, 113
antiqua, 113
Cladochonus, beecheri, 113, 40—18–21
tenuicollis, 113
Cladoidea, 151
Cladophragmus, 61
Cladophyllia, 119
furcifera, 119, 43—26–28
Cladopora, 111
Clappaspis, 609
typica, 609, 255—12
Clarkella, 301
mcgerriglei, 301
montanensis, 301, 114—13, 14
nona, 303
Clarkeocrinus, 201, 70—7
troosti, 201, 74—1
Clarkoceras, 533
newton-winchelli, 533, 217—5
Clathrodictyon, 59
cellulosum, 61, 18—19, 20
cystosum, 59, 18—14
laxum, 61, 18—15
ostiolatum, 59
striatellum, 59, 61, 18—17, 18
vesiculosum, 59, 61, 18—12
vesiculosum minutum, 59, 18—13
Clathrodrillia, 514
abundans, 514
ebenina, 514, 211—10
incilifera, 514, 211—12
incilifera angulata, 514
incilifera distans, 514
limatula, 514, 211—11
limatula disimilis, 514
limatula pyramidalis, 514
ostrearum, 514
Clathropora, 267
frondosa, 267, 101—32–34
Clathrospira, 455
conica, 455, 184—31–33
subconica, 455, 184—34
Clavagella, 415
armata, 415, 165—29, 30
echinata, 415
Clavaspidella, 609
anax, 609, 259—22
howelli, 609, 259—3
sinupyge, 609
Clavator, 713
harrisi, 713, 303—14–16
reidi, 713
Clavella, gravida, 503
Clavilithes, 501, 508
kennedyanus, 501, 206—7
Clavulina, compressa, 18, 2—11
insignis, 18, 2—13
trilatera, 18
Clavulinoides, 18
Cleidophorus, 377
neglectus, 377, 146—18, 19
planulatus, 377, 146—17
Cleiothyridina, 333
hirsuta, 333, 128—1, 2
orbicularis, 335, 128—6–8
sublamellosa, 333, 128—3–5
Clementia, 425
inoceriformis, 425, 170—1, 2
pertenuis, 425, 170—3
Cleodora, 517
Clidochirus, 183, 66—9
americanus, 183, 54—3
keyserensis, 183, 69—18
pyrum, 183
Climacograptus, 71, 75
bicornis, 71, 73, 21—35
eximius, 73
lorrainensis, 73

Climacograptus, parvus, 73, 21—38
putillus, 73, 21—39
pygmaeus, 73
scharenbergi, 73, 21—37
strictus, 73
tenuis, 73
typicalis, 73, 21—34
ulrichi, 73, 21—36
Climactichnites, 719
wilsoni, 719, 303— 37
Clionolithes, 57
hackberryensis, 57, 17—18
Clinopistha, 369
radiata, 369, 144—5, 6
radiata levis, 369
subnasuta, 369, 144—4
Clio, 517
borealis, 517
hastata, 517, 213—32-34
helicina, 517
Clioderma, 445
Clionoides, 57
thomasi, 57, 17—20
Clionolithes, radicans, 57
Clionychia, 385, 387
lamellosa, 387, 150—5
undata, 387, 150—4
Clisiophyllum, 87
oneidaense, 99
Clisiospira, 439
curiosa, 439, 176—1, 2
Clitambonacea, 283
Clitendoceras, 535
saylesi, 535, 218—10
Clithrocrinus, 154
Clithrocytheridea, 689
garretti, 689, 290—15-17
Clonocrinidae, 200
Clonocrinus, 200
occidentalis, 201, 73—13, 24
Closterocrinus, 154
Clymenia, annulata, 565
Clypeaster, 221
bowersi, 221, 84—17, 18
rogersi, 221, 84—14-16
rosaceus, 221
Clypeina, 715
Clypeoceras, 577
pusillum, 579, 237—6-8
Coccocrinus, bacca, 201
Coccoliths, 12, 14—12, 13
Cocconeis, baldjikiana, 301—25
Cochlespira, 513
cristata, 513, 210—31
Cochlespiropsis, 513
Cochliostraca, 366, 439
Codaster, 134
gracilis, 134, 50—1-3
pyramidatus, 134, 50—4, 5
trilobatus, 134
Codiacrinidae, 154
Coelenterata, 58
Coelidium, 459
Coeliocrinus, 159
dilatatus, 159, 55—18
lyra, 159, 57—1
subspinosus, 159, 59—1
ventricosus, 159, 55—20
Coelocaulus, 459
macrospira, 459, 186—23-25
Coelochilina, 673, 675
aequalis, 673, 283—15
striatomarginata, 673, 283—16
Coeloclema, 253
trentonense, 253, 96—8
Coeloconus, 267
Coeloconus, granosus, 267, 101—28
rhombicus, 267
Coelocystis, 129
subglobosus, 129, 48—9-12
Coelosmilia, milneri, 122
Coelospira, 319
concava, 319, 121—19-21
hemisphaerica, 319, 121—22-25
Coelozone, 453
Coenites, 111
cryptodens, 111, 39—13-16
fischeri, 111, 39—19
juniperinus, 111
labiosa, 111, 39—17
laqueata, 111, 39—18
seriata, 111, 39—11, 12
spinulata, 111, 39—9, 10
Coenocystis, 154
Coenograptus, 71
Coleites, 39
reticulosus, 39, 10—1, 2
Coleodontidae, 237
Coleodus, 237
simplex, 237, 93—22
Coleoidea, 366, 528, 595
Coleoloides, 526
typicalis, 526, 214—20, 21
Coleolus, 77, 526
gracilis, 526, 214—18
tenuicinctus, 526, 214—19
Coleoprion, 526
tenuicinctum, 526
Collenella, 715
guadalupensis, 302—35
Collenia, 715, 716
undosa, 717, 303—33, 34
Coloceras, 545
liratum, 545
Colpocaris, 657
bradleyi, 657, 279—16
elytroides, 657, 279—20-24
woodfordi, 657, 279—17-19
Colpomya, 411
constricta, 411, 164—4, 5
Columbites, 579
parisianus, 579, 238—24-26
Columbricrinus, 149
Columnal, dispar, 209, 79—9
excentricus, 209, 79—14
granulosus, 209, 79—13
spicatus, 209, 79—20
Columnaria, 97
alveolata, 99
parva, 105
Comanthocrinus, 201
indianensis, 201, 75—21
Comarocystites, 127
punctatus, 127, 47—24-26
Composita, 335
subquadrata, 335, 128—13-15
subtilita, 335, 128—9-12
trinuclea, 335, 128—16-20
Compsocrinus, 189, 71—5
harrisi, 189, 75—20
miamiensis, 189, 75—19
Conaspis, 621, 633
perseus, 621, 263—27
Conchicolites, 233
Conchidium, 305
binocularis, 305
knighti, 305, 116—5
laqueatum, 305, 116—6, 10-12
occidentale, 305
Conchita, rhomboidalis, 341
Conchopeltis, 77, 79
alternata, 79, 23—1, 2

Conchostraca, 660
Conchyliolithus, resupinatus, 357
sphaericus, 571
Condracypris, 685
bimoda, 685
simplex, 685, 288—25–27
Condylopyge, 600
rex, 600, 251—23, 24; 276—17, 18
Confusastrea, 119
burgundiae, 119
ohioensis, 119, 43—21
Conocardium, 387
cuneus, 389, 150—15–17; 151—1
hibernicum, 387
ohioense, 389, 150—18
Conocephalites, anatinus, 629
baileyi, 607
calymenoides, 627
cordillerae, 611
depressus, 619
elegans, 607
kingi, 611
perseus, 621
shumardi, 633
subcoronatus, 605
teucer, 605
Conocephalus, coronatus, 609
Conocoryphe, 609
kingi, 611
terranovica, 609, 253—5
Conodiscus, 289
burlingi, 289, 108—25–28
Conodontiformes, 239
Conodontophoridia, 237
Conodonts, 235
Conomitra, 509
fusoides, 509, 210—2, 3
staminea, 509, 210—4
Conopeum, 271
lamellosum, 273, 103—13
Conophyllum, 99
Conotreta, 289, 105—13
rusti, 289, 109—1–3
Conradella, 443
Constellaria, 259
constellata, 259, 98—16–20
florida, 259, 98—16–20
varia, 259, 98—14, 15
Conularia, 77, 79
aspersa, 79
crustula, 79, 22—26
huntiana, 77, 22—33, 34
missouriensis, 77, 22—32
niagarensis, 77, 22—27, 28
quadrisulcata, 77
trentonensis, 77, 22—29, 30
undulata, 77, 22—35, 36
Conularida, 58, 77
Conularidae, 77
Conulariella, 77
Conus, 509, 513
adversarius, 514, 211—8
californicus, 514, 211—5
marmoreus, 513
planiceps, 513, 211—3, 4
sauridens, 513, 211—1, 2
spinosus, 508
waltonensis, 513, 211—6, 7
Cooperidiscus, 131
alleganius, 131, 49—16
Coosella, 621
curticei, 621, 264—28
prolifica, 621, 264—16–21
Coosia, 621, 623, 627
connata, 623, 264—23, 24
robusta, 623, 264—26
Coosia, superba, 623, 264—25
Coptothyris, 283
Corallina, 715
Coralliochama, 421
orcutti, 421, 168—17–19
Corbicula, 419
cytheriformis, 419, 167—17–19
durkeei, 419, 167—13, 14
occidentalis, 419, 167—20, 21
Corbisema, 11
geometrica, 11, 14—6
Corbula, 431
aldrichi, 431, 172—13, 14
bisulcata, 431, 172—8, 9
crassiplicata, 431, 172—6, 7
nucleus, 431
oniscus, 431, 172—10, 11
pyriformis, 431, 172—1, 2
subcompressa, 431, 172—12
subtrigonalis, 431, 172—3–5
Cordania, 641
becraftensis, 641, 274—23, 24
Cordylocrinus, 203
comtus, 203
plumosus, 203, 77—27
Cordylodus, 240
angulatus, 240, 93—71
plattinensis, 240, 93—67
Corematocrinus, 167, 169
plumosus, 167, 169, 58—7
Cornellites, 383
chemungensis, 383, 148—19, 20
emaceratus, 383, 148—21
flabella, 383, 148—18
Cornulites, 233
arcuatus, 233, 92—19, 20
bellistriatus, 233, 92—18
cingulatus, 233, 92—13
corrugatus, 233, 92—15, 16
flexuosus, 233, 92—17
minor, 233, 92—14
proprius, 233
serpularius, 233
Cornuspira, 29
planorbis, 29
schlumbergeri, 29
thompsoni, 29, 5—9
Corocrinus, 191
ornatus, 191, 74—3
Coronia, 513
childreni, 513, 210—26, 27
Coronilla, 449
Coronura, 641
aspectans, 643, 274—27
Corynecrinus, 154
Corynoides, 70
calicularis, 70, 21—29
curtus, 71, 21—88
gracilis, 71, 21—27
Corynotrypa, 250
delicatula, 250, 95—3
inflata, 250
Coscinium, 270
cribriforme, 270, 102—13, 14
cylops, 270
latum, 270, 102—12
plumosum, 270
Coscinodiscus, apiculatus, 301—34
asteromphalus, 301—23
Coscinopleura, 273
digitata, 271, 273
Cosmetocrinus, 159
crawfordsvillensis, 159, 58—14
elegantulus, 159, 58—6, 21
gracilis, 159, 58—16
nanus, 159, 58—15

Cosmogoniophora, 411
bellula, 413, 164—12
Costellirostra, 311
peculiaris, 311, 118—44–48
Costispirifer, 323
arenosus, 323, 122—27–31
Cottaldia, rotula, 226, 88—2–4
Cotteroceras, 535
compressum, 535, 218—15
Cradeocrinus, 158
elongatus, 158, 53—18
Cranaena, 281, 364
iowensis, 364, 142—32, 33
romingeri, 364, 142—30, 31
sulcata, 364
Crania, 105—12
permiana, 351
Craniacea, 283, 291
Craniella, meduanensis, 291
Craniidae, 281
Craniops, 293
areolata, 293, 109—35, 36
hamiltoniae, 293
ovata, 293
squamiformis, 293
trentonensis, 293
Craspedodiscus, coscinodiscus, 301—32
elegans, 301—39
Crassatella, 419
sinuata, 419
Crassatellites, 368, 419
gabbi, 419, 167—5
halei, 419, 167—12
linteus, 419
pteropsis, 419, 167—4
uvasana, 419, 167—11
vadosus, 419, 167—1–3
Crassispira, 513
calligona, 513, 210—30
Cremacrinus, 145
articulosus, 145, 55—8
punctatus, 145
tubuliferus, 145, 55—7
Crenella, 413
decussata, 413
elegantula, 413, 164—20, 21
serica, 413, 164—22–24
Crenipecten, 403
amplus, 403, 160—12
Creonella, 480
triplicata, 480, 197—17, 18
Crepicephalus, 623
buttsi, 623, 262—13–15
explicatus, 623, 262—12
iowensis, 623, 262—7, 8
liliana, 611
nitidus, 625
oweni, 629
unca, 635
Crepidula, 445, 489
fornicata, 489, 199—42, 43
lirata, 489, 199—44
onyx, 489
plana, 489, 199—40, 41
princeps, 489, 201—20, 21
Crepipora, 253
simulans, 253, 96—17
Creseis, hastata, 517, 213—32–34
Cribrilina, 275
verrucosa, 275, 104—17
Cribroconcha, 685
costata, 685
fornicata, 685, 288—21–23
Crinoid, apicals, 209
brachials, 209
columnals, 207, 209
Crinoid, composites, 209
facetals, 209
polygonals, 209
symbols, 141, 142, 143
tegminals, 209
Crinoidea, 123, 137
Crisia, 250
hörnesi, 250, 95—6–8
Crisisina, 251
cenomana, 251
triforata, 251, 95—23, 24
Crispella, 327
crispa, 327, 125—18–20
vanuxemi, 327, 125—25
Cromyocrinidae, 175
Cromyocrinus, 175
gracilis, 171
Crotalocrinites, 153
cora, 153, 54—30
Crotalocrinitidae, 153
Crucibulum, 487
auriculum, 487
costatum, 487, 200—31, 32
grande, 487, 200—29, 30
planum, 487
spinosum, 489, 199—39
Crurithyris, 329
planoconvexa, 329, 126—18–20
Crustacea, 599
incertae sedis, 701
Cryphaeus, boothi, 647
Cryphiocrinus, 175
Cryptaulus, 457
Cryptoblastus, 133, 137
granulosus, 137, 51—27, 28
melo, 137, 51—32–34
pisum, 137, 51—35, 36
roemeri, 137, 51—29–31
Cryptocephala, 228, 231
Cryptoceras, springeri, 549
Cryptograptus, 75
tricornis, 75, 22—11
Cryptolithus, 643, 649
bellulus, 643, 267—6, 7
tesselatus, 643, 267—2–5
Cryptonella, 364
attenuata, 364, 142—22
rectirostra, 364, 142—23–26
Cryptophragmus, 61, 63
antiquatus, 63, 19—6–8
Cryptorhytis, utahensis, 507, 208—9
Cryptostomata, 249, 261
Cryptothyrella, 331
cylindrica, 331, 126—52–55
quadrangularis, 331, 126—50, 51
Cryptozoon, 715, 717
proliferum, 717, 303—39
proliferum fieldii, 717
undulatum, 717, 303—35, 36
Ctenobolbina, 669, 671
ciliata, 669, 281—63, 64
granosa, 669
hammelli, 669, 281—66
insolens, 671
loculata, 669, 281—70, 71
Ctenocephalus, 609
howelli, 609, 253—13
Ctenocrinus, 200, 70—12
nobilissimus, 200, 74—15
pachydactylus, 200, 74—11, 14
paucidactylus, 200, 74—12
typus, 200
Ctenodonta, 367, 373
fecunda, 375, 146—8, 9
gibberula, 373, 146—1, 2
nasuta, 373, 146—5

Ctenodonta, obliqua, 375, 146—3, 4
socialis, 375, 146—6, 7
Ctenoloculina, 667
cicatricosa, 667, 281—36, 37
Ctenophora, 58
Ctenopterus, cestrotus, 709, 299—7
Ctenopyge, 623
acadica, 623, 263—5-7
pecten, 623, 262—22, 23
Ctenostomata, 249
Cuccoceras, 579
bonae-vistae, 579, 238—4-7
Cucullaea, 379
antrosa, 379, 147—9
auriculifera, 379
capax, 379
carolinensis, 379, 147—4, 5
gigantea, 379, 147—1, 2
opima, 375
truncata, 379, 147—3
vulgaris, 379, 147—7, 8
Culicocrinus, 203
spinosus, 203, 77—20
Culmicrinus, 159, 52—21
elegans, 159, 59—9
missouriensis, 159, 59—6
Cumingia, 429
lamellosa, 429
medialis, 429, 171—13, 14
Cuneamya, 369
miamiensis, 369, 144—16, 17
Cupulocrinidae, 155
Cupulocrinus, 155, 52—16
heterocostalis, 155, 53—9
humilis, 155, 53—7, 25
jewetti, 155, 53—12
Curtognathus, 239
coronata, 239, 93—15
typa, 239
Cuspidaria, 415
moreauensis, 415, 165—27
ventricosa, 415, 165—26
Cyanophyta, 716
Cyathaxonia, prolifera, 87
Cyathocrinites, 154, 155, 52—12
planus, 154
rugosus, 153
scrobiculatus, 181
tumidus, 154, 57—27
wilsoni, 154, 54—21
Cyathocrinitidae, 154
Cyathocrinoidea, 151
Cyathocrinus, bulbosus, 153
florealis, 161
macrodactylus, 177
magnoliaeformis, 165
ornatissimus, 157
spurius, 154
stillativus, 157, 52—14
Cyathophyllum, 93, 95, 97
caespitosum, 95
dianthus, 93
hexagonum, 95
perfoliatum, 101
profundum, 93
robustum, 95, 29—20, 21
rugosum, 95
vesiculosum, 101
zaphrentoides, 85
Cyathopora, iowensis, 109
Cyathospongia, 56
Cyathus, 665
ulrichi, 665, 280—45-48
Cybeloides, 643
iowensis, 643, 271—22
primus, 643, 271—23, 24
Cyclaster, 131
bigsbyi, 131
Cyclendoceras, 535
annulatum, 535, 218—1, 2
Cycloceras, 539
Cyclocrinites, 719
globosus, 719, 303—22
spaskii, 719
Cyclolobus, 577
oldhami, 577, 237—11, 12
Cyclonema, 471
bilix, 471, 192—30, 31
mediale, 471, 192—27, 28
percingulatum, 471, 192—29
varicosum, 471, 192—25, 26
Cyclopina, 705
vulgaris, 705, 298—5, 6, 12
Cyclorhina, 311
Cyclospira, 317
bisulcata, 317, 120—57-59
Cyclostomata, 249, 250
Cyclostomiceras, 533
cassinense, 533, 217—21-23
Cyclotella, quillensis, 301—42
Cyclotheca, 445
Cyclotropis, 475
Cyclozyga, 463
mirabilis, 463, 187—30
Cydrocrinus, 157
coxanus, 157, 58—18
subramulosus, 157, 58—2
Cylichna, 515
alba, 517, 212—21
scitula, 517, 212—19, 20
secalina, 517, 212—25, 26
Cylicocrinus, 193
canaliculatus, 193, 75—16
Cylindrophyllum, 95
elongatum, 95, 30—8
hindshawi, 95, 30—15
panicum, 95, 30—9, 18
Cylindroteuthis, 595, 597
skidegatensis, 595, 250—3-5
Cylindrotopsis, 479
ovalis, 479
vaningeni, 479, 196—7
Cymatium, pacificum, 505, 207—6
Cymatoceras, carlottense, 549, 224—11
Cymatogonia, amblyoceras, 301—13
Cymatospira, 445, 549
montfortianus, 445, 179—34-41
Cymatosyrinx, 513
lunata, 513, 210—37
Cymbella, mexicana, 301—9
Cymbophora, 431
alta, 431, 171—19, 20
ashburneri, 431, 171—26, 27
emmonsi, 431, 171—24, 25
lintea, 431, 171—23
warrenana, 431, 171—21, 22
Cymella, 415
bella, 415, 165—21, 22
montanensis, 415, 165—23
undata, 415, 165—23
Cymopolia sp., 715, 302—20-23
Cymostrophia, 339
patersqni, 339, 129—8, 9
Cynostraca, 366, 437
Cyphaspis, 643
christyi, 643, 276—11-13
Cyphinium, 645
Cyphocrinus, 187
gorbyi, 187, 72—12
Cyphosoma, 219
Cypraea, 435, 500
pinguis, 500

Cypraea, spadicea, 500, 205—4
tigris, 500
tumulus, 500, 205—5, 6
Cypricardella, 415
bellastriata, 417, 166—4, 5
complanata, 415, 166—1
gregaria, 415, 166—3
oblonga, 417, 166—6
subelliptica, 415
tenuistriata, 415, 166—2
Cypricardia, leidyi, 660
Cypricardiacea, 415
Cypricardinia, 417
arata, 417, 166—13
carbonaria, 417, 166—7
consimilis, 417, 166—8, 9
indenta, 417, 166—10
lamellosa, 417, 166—11, 12
Cypricardites, catskillensis, 399
ovatus, 409
recurva, 414
sectifrons, 369
Cyprimeria, 425
alta, 425, 169—23, 24
crassa, 425
depressa, 425, 169—21, 22
texana, 425, 169—20
Cyprina, 417
Cyrenacea, 419
Cyrtia, 321
exporrecta, 321, 121—38–40
laminosa, 321
Cyrtina, 359
acutirostris, 359, 140—31–34
alpenensis, 359, 140—35, 36
hamiltonensis, 359, 140—37–39
umbonata, 359, 140—40–42
Cyrtoceras, annulatum, 543
hallianus, 557
indianense, 551
jason, 545
lamellosum, 557
manitobense, 561
minneapolis, 557
simplex, 557
undulatus, 545
Cyrtochoanites, 366, 551
Cyrtodiscus, 443
Cyrtodonta, 379, 381
billingsi, 381, 146—58, 59
grandis, 381, 146—60
huronensis, 381, 146—56, 57
rugosa, 379
Cyrtogomphoceras, 561
thompsoni, 561, 230—14
Cyrtograptus, 77
murchisoni, 77
ulrichi, 77, 22—25
Cyrtolites, 439
mitella, 439
ornatus, 439, 175—24, 25
retrorsus, 439, 175—26, 27
Cyrtolithes, atlantoides, 439
Cyrtonella, 439
mitella, 441, 176—3–6
Cyrtoniodus, 240
complicatus, 240, 93—68
Cyrtorizoceras, 557
fultonense, 559, 229—6, 7
minneapolis, 559, 229—4, 5
Cyrtospira, 477
tortilis, 477, 195—16
ventricosus, 477, 195—21
Cyrtospirifer, 321
disjunctus, 321, 122—1–3
monticola, 321, 121—52
Cyrtospirifer, whitneyi, 321, 121—53–55
Cyrtostropha, 457
Cyrtotheca, corrugata, 69
Cystaster, 129
granulatus, 129, 49—9, 10
Cystiphyllum, 81, 99, 101
aggregatum, 101, 33—18
aggregatum caespitosum, 101
americanum, 99, 33—11–13
conifollis, 101, 33—8–10
niagarense, 99, 33—1–5
siluriense, 99
sulcatum, 99, 33—6, 7
vesiculosum, 99, 101
Cystodictya, 270
Cystoidea, 123
Cythere, 687, 688
aurantia, 693
complexa, 689
declivis, 689
gibba, 689
impressa, 691
latissima, 691
lutea, 687, 289—9–12
minna, 683
muelleri, 688
sphenoides, 688
Cytherea, excavata, 425
Cythereis, 687, 688
bassleri, 688, 289—28–30
communis, 688, 289—35–39
cornuta americana, 688, 289—40–43
exanthemata, 688, 289—44–48
garretti, 688, 289—49–51
mcguirti, 688, 289—34
pustulosissima, 688, 289—31, 32
semiplicata, 688, 289—33
vaughani, 688, 289—13–15
Cytherella, 685, 687
bispinulatus, 685
gloria, 685, 288—32
hiwanneensis, 687, 288—42–45
marlboroensis, 687, 288—48–51
missouriensis, 685, 288—32
moremani, 687, 288—46, 47
navarroensis, 687, 288—46, 47
ovata, 687, 288—46, 47
wewokana, 685, 288—32
williamsoniana, 687
Cytherellidae, 663
Cytherelloidea, 687
bastropensis, 687, 289—5
danvillensis, 687, 289—3
leonensis, 687, 289—4
tombigbeensis, 687, 289—6
vicksburgensis, 687, 289—2
williamsoniana, 687, 289—1
Cytheretta, 688
alexanderi, 688, 291—2–6
burnsi, 688, 291—9–13
evergreenica, 688, 291—1
rubra, 688
Cytheridea, 688, 689; 290—1–29
blanpiedi, 689, 290—18–22
floridana, 689, 290—23–25
garretti, 689, 290—15–17
hannai, 693
monmouthensis, 689, 290—1–4
montgomeryensis, 689, 290—12–14
muelleri, 689, 290—9–11
sabinensis, 689, 290—5–8
subovata, 689, 290—26–29
Cytherideis, 689
ashermani, 689, 290—33–36
bartonensis, 691
equalis, 689, 290—31, 32

Cytherideis, mayeri, 689, 290—30
subulata, 689
Cytherina, ornatissima, 688
ovata, 687
Cytheropteron, 691, 693
bilobatum, 691, 292—3–5
convexum, 691
galericulum, 693, 292—15
latissimum, 691, 292—1, 2
midwayense, 691, 292—14
montgomeryense, 693, 292—16–21
navarroense, 691, 292—6, 7
trinitiense, 691, 292—8–10
variosum, 693, 292—11–13
Cytherura, 689
byramensis, 689, 291—19
cretacea, 689, 291—23, 24
wardensis, 689, 291—20–22
Cytocrinus, 200
laevis, 200, 73—15
Cyttarocrinus, 203
eriensis, 203, 77—22

D

Dactylocrinus, 179, 181, 67—5
alpena, 181, 69—14
concavus, 181, 68—1
Dactylogonia, 341
geniculata, 341, 132—14, 15
Daedalocrinus, 145, 52—7
kirki, 145, 52—7
Dakoticancer, 699
overana, 699, 297—15
Dallina, 106—4
Dallinella, 365
obsoleta, 365, 143—42, 43
Dalmanella, 353
edgewoodensis, 353, 138—28–30
szajnochai, 357
Dalmanellacea, 283, 284, 351
Dalmania, socialis, 643
Dalmanites, 643, 649
achates, 635
halli, 643, 273—7–10
intermedius, 645
limulurus lunatus, 643, 273—32
stemmatus, 653
verrucosus, 643, 273—27–29
vigilans, 643, 273—13–16
Dalmanitina, 643
arkansana, 643, 273—18, 19
Daonella, 393
americana, 393, 152—28
dubia, 393, 153—1
lommeli, 393, 153—1
moussoni, 393
Daraelites, 569
meeki, 569
texanus, 569
Dasciocrinus, 161
florealis, 161, 61—4
Dawsonia, 609
dawsoni, 609, 252—10–12
lobatus, 609, 252—2, 3
Dawsonoceras, 539
americanum, 539, 220—10
hyatti, 539, 220—8
Decadocrinus, 169, 171, 52—17
bellus, 169, 64—25
gregarius, 169, 60—18
halli, 169, 59—8
nereus, 169, 64—16
repertus, 169, 64—26
spinulifer, 169, 60—12
tumidulus, 169, 59—7
Decapoda, 697
Defonticeras, 585
defontii, 585, 241—6, 7
Deiroceras, 555
python, 555, 228—1
remotiseptum, 555, 228—2
Deissella, 609
convexa, 609, 255—15
Dekayella, 258
obscura, 258, 97—32–33
praenuntia, 258, 97—28–31
praenuntia echinata, 97—28, 29
praenuntia multipora, 97—30
praenuntia simplex, 97—31
ulrichi, 258
Dekayia, 258
aspera, 258, 98—7
Delocrinus, 171, 173, 62—25
abruptus, 167, 173, 62—33; 65—17
benthobatus, 171, 65—29
bispinosus, 171, 65—8
granulosus, 171, 65—13
graphicus, 173, 65—16
matheri, 171, 65—11
missouriensis, 173, 62—24; 65—14
papulosus, 171, 65—26
pentanodus, 163
pictus, 171, 173, 65—12
quadratus, 173, 65—9
somersi, 171, 65—15
subhemisphericus, 173, 62—30; 65—7
verus, 173, 65—6
vulgatus, 173, 65—19
Deloia, 679
serrata, 679, 285—16–19
Delphinula, trigonostoma, 514
Deltacrinus, 145
clarus, 145, 57—8
Deltatreta, typica, 298
Delthyris, 321, 327
elevata, 327
fimbriatus, 327
granulosa, 323
mucronata, 321
perlamellosa, 327, 125—21, 22
sulcata, 327, 125—23, 24
Dendraster, 223
excentricus, 223, 85—16, 17
gibbsi, 223, 85—1, 2
Dendrocrinidae, 155
Dendrocrinoidea, 155
Dendrocrinus, 155, 52—6
longidactylus, 155, 52—6
Dendrograptus, 65
edwardsi, 67
flexuosus, 67, 20—19
hallianus, 65, 20—15, 16
succulentus, 67
Dendroidea, 65
Dendropora, 111
explicita, 111
ornata, 111, 39—3, 4
Denisonia, 679
cincta, 679
cirrata, 679, 285—23
Dentaliidae, 521, 525
Dentalina, 31
communis, 31, 6—7
foedissima, 13
obliqua, 31
Dentalium, 521, 523
attenuatum, 523, 214—11
caduloide, 523, 214—14, 15
canna, 523, 214—31
cooperi, 523, 214—22, 23
elephantinum, 521
gracile, 523, 214—8–10

Dentalium, martini, 521, 214—16
mediaviense, 523, 214—24, 25
minutistriatum, 523, 214—12, 13
pauperculum, 523, 214—7
stramineum, 523, 214—5, 6
subarcuatum, 523, 214—1–4
thalloide, 523, 214—17
trachea, 491
Depranella, 667
crassinoda, 667, 283—1–3
Derbyia, 345
bennetti, 345, 133—17–19
crassa, 345, 133—20, 21
cymbula, 345, 134—1–5
regularis, 345
Desmidocrinidae, 193
Desmograptus, 65, 67
cadens, 67, 20—21
cancellatus, 67, 20—14
micronematodes, 67, 20—17, 18
Desmorthis, 299
nevadensis, 299, 112—34–39
Devonaster, 211
eucharis, 211, 80—9–11
Devonoblastus, 135
leda, 135, 51—1
Devonoproductus, 349
Diabolocrinus, 185
perplexus, 185, 72—15
vesperalis, 185, 72—16
Diamesopora, 271
dichotoma, 271, 103—1–3
vaupela, 253
Diaperoecia, 251
varians, 251, 95—26
Diaphelasma, 303
pennsylvanicum, 303, 114—24–28
quebecense, 303
Diaphorostoma, 473
niagarense, 473, 193—1, 2
Diaphragmus, 349
cestriensis, 349, 135—42–45
Diastoporina, 250
flabellata, 250, 95—12
Diatomaceae, 712, 301
Diboibina, 675
cristata, 675, 283—37, 38
Dibranchia, 366, 528, 595
Dibunophyllum, 87
muirheadi, 87
valeriae, 89, 25—23–25
Dicellocephalus, finalis, 643
iole, 635
Dicellograptus, 71
complanatus, 71, 21—30
divaricatus, 71, 21—23
gurleyi, 71, 21—22
mensurans, 71, 21—19, 20, 31
sextans, 71, 21—21
Dicellomus, 285
politus, 285, 107—8–14
Dichocrinidae, 197
Dichocrinus, 197, 199, 71—17
cornigerus, 199
delicatus, 197, 78—2
inornatus, 197, 78—7
liratus, 199, 78—4
plicatus, 197, 199, 78—5
polydactylus, 199
radiatus, 197
striatus, 197, 78—3
Dichognathus, 243
prima, 243
typica, 243, 94—10
Dichograpsus, aranea, 69
sedgwicki, 69

Dichograptus, 69
octobrachiatus, 69, 70, 21—4
Dichostreblocrinus, 154
scrobiculus, 154, 56—7
Dichotomosphinctes, elizabethseformis, 587, 242—10–12
Dichotrypa, 270
foliata, 270
lyroides, 270, 102—22–24
Dicinocarina, 659
Dicranella, 669
bicornis, 669, 281—61, 62
bivertex, 669, 281—65
Dicranograptus, 71
nicholsoni, 71, 21—32
ramosus, 71, 21—25
spinifer, 71, 21—33
Dictyocha, 11
fibula, 11, 14—15
fornix, 11
specula, 11
Dictyoclostus, 349, 350
americanus, 350, 136—15–19
bassi, 350, 136—22
burlingtonensis, 350, 136—1–3
fernglenensis, 350, 136—4–6
inflatus, 350, 136—9–14
portlockianus, 350, 136—7, 8
Dictyocoryne, profunda, 48, 14—22
Dictyograptus, cancellatus, 67
Dictyonella, 307
reticulata, 307, 117—22–24
Dictyonema, 65, 67
crassibasale, 65, 20—2
crassum, 65, 20—11
flabelliforme, 65, 20—6
flabelliforme anglica, 65, 20—3
hamiltoniae, 65, 20—13
minnesotense, 65, 20—1
retiforme, 65, 20—12
Dictyonina, 287
pannula, 287, 108—12–14
Dictyophyton, sceptrum, 55
telum, 55
Dictyospongia, 49, 55
sceptrum, 55, 16—36
Didymograpsus, elegans, 71
thureaui, 69
Didymograptus, 70
artus, 70, 21—16
bifidus, 70, 21—17
nitidus, 70, 21—14
patulus, 70, 21—13
protobifidus, 70, 21—18
sagitticaulis, 70, 21—15
serratulus, 70, 21—12
Dielasma, 364
bovidens, 364, 143—6–8
formosum, 364, 143—11–13
illinoisense, 364, 143—9, 10
Dielasmella, 364
calhounensis, 364, 143—14–16
Dielymella, 657
recticardinalis, 657, 278—13
Diestoceras, 559
indianense, 559, 229—16, 17
Dikelocephalus, 1, 621, 623, 629
crassimarginatus, 633
gracilis, 623, 261—3, 4
granulosus, 631
iowensis, 623
lodensis, 631
minnesotensis, 1, 623, 261—7, 8
misa, 631
norwalkensis, 623, 261—1, 2
osceola, 629
oweni, 623, 261—12

Dikelocephalus, pepinensis, 633
roemeri, 625
spiniger, 621
Dimegelasma, 359
neglectum, 359, 141—1–5
Dimerocrinites, 187
arborescens, 187, 72—5
decadactylus, 187
inornatus, 187, 72—4
oligoptilus, 179
planus, 187, 72—7
Dimerocrinitidae, 187
Dimorphoceras, 571, 575
politum, 575, 236—3, 4
texanum, 575
Dinobolus, 285, 287
conradi, 285, 107—22–24
Dinorthis, 282, 297, 298
atavoides, 298, 111—42–44
meedsi, 298
pectinella, 298, 111—47, 48
traversa, 298, 111—45, 46
Dinotocrinus, 161
compactus, 161, 61—12
Diodora, 480
aspera, 480, 197—13
griscomi, 480, 197—11, 12
marylandica, 480
Diparelasma, 299
typicum, 299, 112—31, 32
Diphuicrinus, 173
Diphyllum, arundinaceum, 95
Diplapatokephalus, 643
finalis, 643, 267—42, 43
Dipleura, 643
dekayi, 643, 272—26–31
Diploastrea, 115
crassolamellata, 117, 42—17, 18
harrisi, 117, 42—19
Diplobathra, 183
Diplodella, 240
alternata, 240, 93—64, 65
bilateralis, 240
Diplodonta, 423
Diplograptus, 64, 73, 75
amplexicaulis, 73, 22—8–10
angustifolius, 73, 22—22
calcaratus, 73, 21—1
dentatus, 73, 21—4, 5
euglyphus, 73, 22—2
foliaceus, 73
nexus, 73, 22—3
peosta, 73, 22—6, 7
pristiniformis, 73
pristis, 73, 75
tricornis, 75
Diploneis, exempta, 301—2
ornata, 301—3
Diplopholeos, 273
Diplophyllum, 99
caespitosum, 99, 32—11, 12
Diplopora, 715
annulata, 302—3–10
Diploporaria, 265
bifurcata, 265, 100—22
Diploporita, 129
Diploschiza, 407
cretacea, 407, 163—3–6
Diplotrypa, infida, 257
Dipterophyllum, 85
glans, 85, 23—31–33
Diraphora, 295
bellicosta, 295, 110—38
Discinacea, 283, 289
Discinisca, 281, 291
lugubris, 291, 109—22, 23
Discocyclina, 47
advena, 47, 12—14, 15
bainbridgensis, 47
georgiana, 47, 12—10
mariannensis, 47, 12—18
Discocystis, 131
kaskaskiensis, 131, 49—19, 20
Discolites, 439
Discoporella, 273
umbellata, 273, 103—24
Discorbis, 37, 41
subaraucana, 37, 9—1
vesicularis, 37
Discoscaphites, 589
conradi, 589, 243—17–19
nicolleti, 589, 243—10–12
Discosorus, 561
austini, 561, 230—16
conoideus, 561, 230—3, 4
Discotrochus, 117
californicus, 117, 43—4–6
orbignianus, 117, 43—1–3
Discotropites, 581
sandlingensis, 581, 239—4–6
Disculina, 365
Discus, sangamonensis, 547
Disparata, 143
Disphyllum, 95
occidens, 95, 29—22, 23
Distacodidae, 239
Distacodus, romboideus, 239
sp., 239, 93—40, 41
Distemnostoma, 473
Distephanus, 11
ornamentatus, 11, 14—19
Distoloceras, 587
irregulare, 587, 243—13, 14
Dithyrocaris, permiana, 671
Ditomopyge, 645, 653
decurtata, 645, 275—1, 2
lansingensis, 645
olsoni, 645, 275—3
scitula, 645, 275—4–6
Diversophyllum, 93
traversense, 93, 28—27–29
Dizygocrinus, 197
indianaensis, 197, 75—3
rotundus, 197, 75—2
Dizygopleura, 679
swartzi, 679, 284—31–35
symmetrica, 679, 284—36, 37
Dokimocephalus, 623
gregori, 623, 264—38, 39
Dolatocrinidae, 201
Dolatocrinus, 201, 70—16
argutus, 201, 74—19
bellulus, 201, 74—21
bulbaceous, 201, 74—18
lacus, 201, 74—20
lyoni, 201, 74—17
marshi, 201, 74—22
speciosus, 201, 74—16
Dolatophycus, 717
expansus, 717, 303—28, 29
Doleroides, 299
gibbosus, 299, 112—48–51
ottawanus, 299
Dolerorthis, 297
flabellites, 297, 111—6–8
interplicata, 297
Dolichometopsis, 609
gravis, 609, 258—15
resseri, 609
Dolichometopus, boccar, 611
tontoensis, 605
varro, 625

Doliognathus, 244
lata, 244, 94—50, 51
Dolorthoceras, 553
circulare, 553
exile, 553, 226—6
Domatoceras, 549
lasallense, 549, 224—9, 10
umbilicatum, 549
Donaldiella, 449
bowdeni, 449, 182—20–22
Donaldina, 463
robusta, 463, 187—27–29
stevensana, 463, 187—25, 26
Donax, sulcata, 401
Dorocidaris, 219
papillata, 219
texanus, 219, 226, 83—8–11
Dorothia, 18
bulletta, 18, 2—14
Dorycrinus, 195, 71—9
immaturus, 195
mississippiensis, 195, 76—6
missouriensis, 195, 76—7
unicornis, 195, 76—5
Dorypyge, desiderata, 607
Dosinia, 427
africana, 427
mathewsonii, 427, 173—1
Dosiniopsis, 427
lenticularis, 427, 170—13–15
meeki, 427, 170—13–15
stewartvillensis, 427, 170—16
Douvilleiceras, 591
mammillatum, 591, 244—9
Douvillina, 341
arcuata, 341, 132—4–7
filifer, 341
inaequistriata, 341, 132—8–11
Douvillinella, 341
variabilis, 341, 132—12, 13
Dozierella, 385
gouldi, 385, 149—11, 12
Dreissena, 413
tippana, 413, 164—28–30
Drepanella, 677
Drepanellina, 677
clarki, 677, 284—41, 42
Drepanochilus, 497
americanum, 497, 203—24
americanum pusillum, 497, 203—25
evansi, 497
Drepanodus, 239
arcuatus, 239, 93—42
inflexus, 239
Dresbachia, 623
amata, 623, 264—22
Drillia, 513
umbilicata, 513
Drilluta, 513
communis, 513, 210—35, 36
Drumaspis, 623
idahoensis, 625, 264—31, 32
walcotti, 623, 264—33
Drymocrinus, 145, 52—7
geniculatus, 145, 52—7
Dryphenotus, macrolobatus, 245, 94—69
Dufrenoya, 589
justinae, 589, 243—15, 16
Dunbarella, 403
rectilaterarius, 40, 160—4, 5
Duncanella, 83
borealis, 83, 23—10
Duncania, 479
Dunderburgia, 625, 627
nitida, 625, 246—29, 30
Dungulia, 122
Dungulia, texana, 122, 45—33–37
Duplophyllum, 85
septarugosum, 87, 24—21–24
Durangites, 587
acanthicus, 587
astillerensis, 587, 242—8, 9
Dysodonta, 366, 409
Dystactocrinus, 149, 52—11
constrictus, 149, 52—11

E

Earlandia, 13
perparva, 13, 1—5
Eatonia, 311
medialis, 311, 118—41–43
Ebria, 11
antiqua, 11, 14—16
Ecculiomphalus, 467
beloitensis, 467, 189—23–25
bucklandi, 467
owenanus, 467, 189—26, 27
triangulus, 467, 189—21, 22
volutatus, 467, 189—28–30
Eccylopterus, 467
Echinarachnius, 223
fairbanksi, 223, 84—10
Echinites, depressus, 221
Echinocaris, 657
punctata, 659, 279—42
socialis, 659, 279—32, 39
sublevis, 657, 279—37, 38, 41
Echinocoelia, 329
ambocoelioides, 329, 126—27–31
Echinoconchus, 350
alternatus, 350, 137—10–12
biseriatus, 350, 137—6–9
semipunctatus, 350, 137—13–15
Echinocrinus, 217
aculeata, 217, 82—7–12
agassizi, 217, 82—1–3
dininni, 217, 82—4, 5
halliana, 217, 82—13–15
shumardiana, 217, 82—6
Echinocystites, 129
nodosus, 129
Echinoderma, 123
Echinodiscus, 131
emarginatus, 223
optatus, 131
quinquies perforata, 223
subrotundus, 221
Echinoidea, 123, 213
Echinolichas, 645
eriopis, 645, 270—15, 16
Echinosphaerites, 127
aurantium, 127, 47—20, 21
Echinus, aurantium, 127
cidaris, 219
miliaris, 221
milleri, 219
rosaceus, 221
sphaera, 89—45
Echiurida, 228
Ecphora, 505
quadricostata, 505, 208—3
quadricostata umbilicata, 505, 208—4
tricostata, 505, 208—5
Ectenocrinus, 145, 52—7
simplex, 145, 52—7; 53—8
Ectenolites, 533
subgracile, 533, 217—13
Ectinochilus, 497
laqueatum, 497, 203—19
macilentum, 497, 203—20, 21
Ectodermites, 673
primus, 673, 282—49, 50

Ectomaria, 459
pagoda, 461, 186—12, 13
prisca, 459, 186—14
Ectoprocta, 249
Edmondia, 373
aspinwallensis, 373, 145—5, 6
philipi, 373, 145—8
subovata, 373, 145—7
Edrioaster, 131
bigsbyi, 133, 49—24
Edrioasteroidea, 123, 129
Edriocrinidae, 205
Edriocrinus, 205
dispansus, 205, 79—33
pocilliformis, 205
pyriformis, 205, 79—28
sacculus, 205, 79—27
Eiffelia, 55
globosa, 55, 16—31
Egesta, 425
inoceriformis, 425, 170—1, 2
pertenuis, 425, 170—3
Egouena, virginiana, 509, 210—6
Ehmania, 609
gallatinensis, 611, 255—18, 19
weedi, 609
Ehrenbergina, 41
serrata, 41
spinosissima, 41, 10—7
Elasmonema, 469
bellatulum, 471, 192—24
elegans, 471, 192—22, 23
Eleusoceras, 561
nicholsi, 561, 230—5
Eleutherocrinus, 133
Eleutherozoa, 123, 211
Elibatocrinus, 159
catactus, 159, 57—25
leptocalyx, 159, 57—28; 62—23
Elkania, 285
desiderata, 285, 107—18, 19
Elliptio, douglassi, 399, 158—5, 6
hamili, 399, 158—7, 8
priscus priscus, 399, 158—15, 16
Elphidiella, 33
hannai, 33, 7—15
Elphidium, 33
discoidale, 33, 7—9
Elrathia, 605, 609, 611
kingi, 611, 255—5, 6
Elrathiella, 609, 611
buttsi, 611, 255—1
nitida, 611, 255—17
obscura, 611
Elrathina, 611
cordillerae, 611, 255—4
Elrodoceras, 551
indianense, 551, 226—12, 13
Elvinia, 625
matheri, 625, 264—40
roemeri, 625, 264—34–37
shumardi, 625, 264—41, 42
Elysastraea, 119
fischeri, 119
vancouverensis, 119, 43—29–31
Elytha, 282, 327, 329
fimbriata, 327, 126—1–3
Emanuella, 329
pennsylvanica, 329, 126—38, 39
subumbona, 329, 126—32, 33
takwanensis, 329
Embolobranchiata, 599, 709
Emmonsia, 107
emmonsi, 107, 38—1–5
epidermata, 109
hemisphaerica, 107
Emmonsia, tuberosa, 109, 38—6, 7
Emperoceras, 593
beecheri, 593, 246—12, 13
Emperocrinus, 185
indianensis, 185, 72—14
Enallaster, 225, 226
texanus, 226, 86—16–18; 89—20, 21
Encoelioides, fucoides, 717
Encope, 223
grandis, 223
macrophora, 223, 86—1, 2
micropora, 223, 86—3
Encrina, godoni, 134
Encrinites, parkinsoni, 205
Encrinurus, 645
ornatus, 645, 271—3–7
Endelocrinus, 173
allegheniensis, 173, 65—5
bifidus, 173, 65—2
fayettensis, 173, 62—20; 65—4
grafordensis, 173, 65—3
parvus, 173, 65—1
texanus, 173, 65—10
Endoceras, 533, 535
annulatum, 535
fulgur, 535, 217—20
multitabulatum, 535
proteiforme, 533, 217—17–19
Endodesma, 414
cuneatum, 414, 165—13, 14
Endolobus, 547
coxanus, 547, 223—15, 16
forbesianus, 547, 223—17, 18
gibbosus, 545
peramplus, 547
spectabilis, 547, 223—13
Endopachys, 122
maclurii, 122, 46—20, 21
Endosiphonacea, 415
Endothyra, 15
baileyi, 15
bowmani, 15, 17
media, 17, 1—17
Engonoceras, 593
pierdenale, 593, 248—1–3
Ennalaster, 225
Ensis, 431
directus, 431, 173—2, 3
ensiformis, 431, 172—17, 18
magnus, 431
Entalophora, 251
cellarioides, 251
proboscidea, 251, 95—22
Enteletes, 282, 357, 140—12–15
choristites, 357
hemiplicatus, 357, 140—16–18
Entelophyllum, 99
rugosum, 99, 32—14–16
Enterolasma, 85
caliculum, 85, 24—11–13
strictum, 85, 24—14–16
Entolium, 405
operculiformis, 405, 161—1
semiplicatus, 405, 161—3
Entomaspis, 625
radiata, 625, 265—1–3
Entomis, 687
serratostriata, 687, 289—7, 8
tuberosa, 687
Entomolitus, paradoxus pisiformis, 600
Entomostracites, crassicauda, 647
laciniatus, 649
punctatus, 645
scarabaeoides, 629
spinulosus, 629
Entoprocta, 249

Entopyla, australis, 301—10
Entosolenia, 35
crumenata, 35, 6—15
lineata, 35
Eoagnostus, 600
roddyi, 600, 251—15
Eoasianites, 573
angulatus, 573, 235—20, 21
globulosus, 573, 235—15–17
modestus, 573
ruzencevi, 573, 235—18, 19
subhanieli, 573
welleri, 573, 235—13, 14
Eocryptaenia, 451
Eocryptaulina, 457
Eocystites, 125
longidactylus, 125, 47—7, 8, 27
primaevus, 125, 47—28, 29
Eocytheropteron, 691
bilobatum, 691, 292—3–5
trinitiense, 691, 292—8–10
Eodevonaria, 347
arcuata, 347, 135—3–5
Eodiscus, 611
punctatus, 611, 252—1
schucherti, 611
speciosus, 611, 252—4–6
Eoharpes, 625, 645
ottawaensis, 645, 267—1
Eomonorachus, 645
intermedius, 645, 273—30, 31
Eoorthis, 295
bellicosta, 295
lineocosta, 295
remnicha, 295, 110—29–33
Eophacops, 645
handwerki, 645, 274—7, 8
Eopteria, 659
richardsoni, 659, 297—7, 8
typica, 659
Eoptychia, 461
rothi, 461, 186—27
trochus, 461, 186—26
Eoradiolites, davidsoni, 421, 168—16
Eoscorpius, 709
carbonarius, 709, 300—10–12
Eoscutella, 223
coosensis, 223, 85—3
Eospirifer, 319, 321
eudora, 321
macropleurus, 321, 121—56
niagarensis, 321
radiatus, 321, 121—47–49
Eospongia, 51, 53
roemeri, 51, 53, 15—4
Eostellaria, 499
Eothalassoceras, 575
kingorum, 575, 236—9, 10
Eotomaria, 455
canalifera, 455, 184—13, 14
dryope, 455, 184—18, 19
galtensis, 455, 184—20
supracingulata, 455, 184—15–17
Eouvigerina, 35
americana, 35, 8—10
Ephippioceras, 545
ferratum, 545, 223—4, 5
Ephippiorthoceras, 539
laddi, 539, 220—1
Epiaster, 225
californicus, 225, 87—4–6
trigonalis, 225
whitei, 225, 226, 87—1–3; 89—6
Epitonium, 481
pachypleura, 481, 197—29
sayanum, 481, 197—28
Epitonium, sillimani, 481, 197—26, 27
tinctum, 481, 197—24, 25
Eponides, 39
alabamensis, 39, 9—7
Epyrhyton, 715
Eratocrinus, 165
commaticus, 165, 61—3
elegans, 165, 59—12; 61—13
serratus, 167, 60—11
Eretmocrinus, 195
magnificus, 195
remibrachiatus, 195, 76—20
tentor, 195, 76—12
Eridophyllum, 89, 95
archiaci, 91, 27—11–14
colligatum, 91, 27—6–10
rugosum, 99
seriale, 89, 27—1–5
verneuilianum, 89
Eridotrypa, 258
aedilis, 258, 98—21, 22
mutabilis, 258, 98—21, 22
obliqua, 258
Eridotrypella, 258
obliqua, 258, 98—28, 29
Erismodus, 237
sp., 237, 93—14
typus, 237
Erisocrinidae, 171
Erisocrinus, 173, 62—26
elevatus, 173, 65—27
typus, 173, 62—27; 65—28
Errantia, 229
Escasona, 657
Eschara, elegans, 273
eurita, 275
spongites, 275
Escharopora, 267
falciformis, 267, 101—20, 21
pavonia, 267, 101—25, 26
recta, 267
subrecta, 267, 101—22–24
Escheria, insignis, 226
Esmeraldina, 611
macer, 611, 252—19
Estheria, 660
dahalacensis, 660
membranacea, 660, 279—13–15
ortoni, 660, 279—10–12
ovata, 660
Etea, 417
carolinensis, 417, 166—23, 24
Eteraspis, 611
glabra, 611, 255—23, 24
laeviceps, 611, 255—20
Ethelocrinus, 175
magister, 175, 65—33
oklahomensis, 175
sphaeralis, 175, 65—30
texasensis, 175, 65—31
Ethmocardium, whitei, 423, 169—6
Ethmophyllum, 57
whitneyi, 57, 17—19
Etymothyris, 363
gaspensis, 363, 142—5–7
Eucalyptocrinites, 201, 71—2
crassus, 201, 75—24
rosaceus, 201
Eucalyptocrinitidae, 201
Eucalyptocrinus, polydactylus, 200
Eucarida, 697
Eucatillocrinus, 149
bradleyi, 149, 55—3
Eucheirocrinus, 145
schryalis, 145, 55—6
Euchondria, 403

Euchondria, neglecta, 403, 160—11, 15
Eucidaris, thouarsi, 89—41, 42
Eucladocrinus, 205
millebrachiatus, 205, 78—29
montanensis 205
pleurovimineus, 205, 78—28
tuberosus, 205, 78—30
Eucochlis, 471
perminuta, 471, 193—20
Euconia, 449
etna, 449, 181—24
Euconospira, 457
turbiniformis, 457, 185—11
Eucyclotropis, 475
Eucythere, 689
brightseatensis, 689, 291—15
brownstownensis, 689, 291—14
chickasawhayensis, 689, 291—18
woodwardensis, 689, 291—16, 17
Eucytherura, 689
chelodon, 691, 291—25, 26
murdercreekensis, 691, 291—7, 8
Eudimerocrinus, 187, 70—3
multibrachiatus, 187, 72—6
Euerisocrinus, 173
Eugastropoda, 366, 439
Eugeniacrinites, costatus, 201
Euglyphella, 681
sigmoidalis, 681, 286—7
sigmoidalis primitiva, 681
Eukloedenella, 677
sinuata, 677, 284—9, 10
umbilicata, 677, 284—5-8
Eulepidina, 45
favosa, 47, 12—19, 20
undosa, 47, 13—13
Eulima, peracuta, 477
Euloxoceras, 553
greeni, 553, 227—2, 3
Eumargarita, 480
Eumetria, 361, 141—42
altirostris, 361, 141—35-37
vera, 361, 141—38-41
Eumicrotis, hawni, 393, 152—24
Eumorphoceras, 571
bisulcatum, 571, 233—16-18
Eumorphocystis, 129
multiporata, 129, 48—22-24
Eunella, compressa, 364
Eunema, 451
fatuum, 451, 182—37
nitidium, 451, 182—35, 36
salteri, 475
strigillatum, 451, 182—31
Eunicites, 229
avitus, 229
clintonensis, 229, 91—24
contortus, 229, 91—25
coronatus, 229, 91—26
falcatus, 229, 91—32
gracilis, 229, 91—31
grandis, 229, 91—27
major, 229, 91—28
nanus, 229, 91—23
palmatus, 229, 91—29
simplex, 229, 91—22
tumidus, 229, 91—30
Eunotia, diodon, 301—8
Euomphalopterus, 467
obsoletus, 467, 191—8-10
Euomphalus, 465
angelini, 465
decewi, 465
discors, 475
latus, 465, 188—15
pentangularis, 465
Euomphalus, pernodosus, 465, 188—20-22
planidorsatus, 465, 188—13, 14
plummeri, 465, 188—32, 33
reedsi, 465
similis, 465, 188—10-12
umbilicatus, 465, 188—18, 19
Eupachycrinidae, 175
Eupachycrinus, 175, 209
asperatus, 175, 64—34
fayettensis, 173
14-brachialis, 175, 64—33
magister, 175
spartarius, 175, 64—28
Eupatagus, 226
floridanus, 226, 87—22-24
valenciennesii, 226
Euphemites, 445
lentiformis, 445, 179—27, 28
nodocarinatus, 445, 179—32, 33
vittatus, 445, 179—29-31
Euphemus, 445
Euphoberia, 701
armigera, 701, 294—9-11, 23, 24
granosa, 701, 294—21
Euprioniodina, 240
deflecta, 240, 93—66
Euproöps, 707
danae, 707, 300—5
Eupsammia, 122
Euptychaspis, 625
typicalis, 625, 264—27
Eurekia, 625
eos, 625, 265—4-6
granulosa, 625, 265—13, 14
Euritina, 275
torta, 275, 104—2
Eurychilina, 673
aequalis, 673
reticulata, 673, 283—20
subradiata, 675, 283—17-19
ventrosa, 675, 283—21, 22
Eurymya, 411
plana, 411, 164—8, 9
Eurymyella, 411
shaleri, 411, 164—7
Euryocrinus, 179, 67—1
barrisi, 179, 68—22
concavus, 179
tennesseensis, 179, 68—23
Eurypterida, 707
Eurypterus, 707, 709
eriensis, 707, 299—12, 13
lacustris, 707, 299—10
maxonensis, 707
micropthalmus, 707, 299—12, 13
remipes, 707, 299—1, 2
Euryrizoceras, 559
chadwicki, 559, 229—8, 9
orodes, 559
Eurystomites, 541
kelloggi, 541, 221—12
Euryzone, 453
arata, 453, 183—38, 39
rugulata, 453, 183—28
Euspira, halli, 483, 198—23, 24
Eutaxocrinus, 177, 67—14
fletcheri, 177, 68—10
ithacensis, 177, 69—4
whiteavesi, 177, 68—16
Eutrephoceras, 549
alcesense, 549, 225—4, 5
dekayi, 549, 225—1-3
dekayi mortonense, 549
Eutrochocrinus, 197, 71—7
christyi, 197, 75—8; 76—21
Evactinopora, 270

Evactinopora, grandis, 270, 103—12
radiata, 270, 271, 103—8–11
Exiteloceras, 593
pariense, 593, 246—7–9
Exochops, 645, 651
portlocki, 645, 276—7
Exocycloida, 221
Exogyra, 397
arietina, 397, 156—11, 12
cancellata, 399, 156—15; 157—4
columbella, 397, 156—1–3
costata, 4, 231, 233, 397, 399, 156—13, 14; 157—2, 3
laeviuscula, 397, 156—4, 5
olisiponensis, 397, 156—6
ponderosa, 233, 397, 156—9, 10; 157—1
texana, 397, 156—7, 8
Extrasiphonata, 366, 565

F

Facetal, canalis, 209, 79—23
corrugatus, 209, 79—16
lineatus, 209, 79—18
tuberculatus, 209, 79—15
Falsifusus, 507
meyeri, 507, 208—16
Fanninoceras, 585
fannini, 585, 241—11, 12
Fardenia, 343
scotica, 343
subplana, 343, 132—36–40
Fasciculiconcha, providencesis, 401, 159—20
Fascifera, 357
subcarinata, 357, 139—35–39
Fasciolaria, 507
culbertsoni, 507, 208—10, 11
rhomboidea, 507, 208—8
utahensis, 507, 208—9
Favistella, 97
alveolata, 99, 32—4, 5
halli, 99, 32—3, 8, 9
stellata, 97, 99, 32—6, 7
Favositella, 253
laxata, 253, 96—10
Favosites, 83, 105, 107, 109
aspera, 107, 37—16
canadensis, 107, 37—9, 10
emmonsi, 107
favosus, 1, 105, 107, 36—10–12
gothlandicus, 105
hamiltoniae, 107, 37—6–8
helderbergiae, 107, 37—1, 2
hemispherica, 107
interpuncta, 253
limitaris, 107, 37—14, 15
niagarensis, 107, 36—13–17
placenta, 107, 37—11–13
prolificus, 107
turbinatus, 107, 37—5
winchelli, 107, 37—3, 4
Favositidae, 105
Favulella, 682
favulosa, 682, 286—37–41
Fenestella, 263
cinctuta, 264
crassa, 263
lata, 263
perforata, 263
subquadrans, 264
Fenestralia, 264
sancti-ludovici, 264, 100—25
Fenestrapora, 263
biperforata, 263
occidentalis, 263, 99—34
Fenestrellina, 263, 264
cestriensis, 263, 99—24
elegans, 263, 99—22, 23
Fenestrellina, emaciata, 263, 99—26, 27
mimica, 263, 99—25
stellata, 263, 99—28
tenax, 263, 99—29, 30
Ficopsis, 500
penita, 500, 205—17
remondi, 500, 205—15, 16
Ficus, 500
intermedia, 500
mississippiensis, 500, 205—23
Filifascigera, 251
megaera, 251, 95—27, 28
Fimbrispirifer, 323
divaricatus, 323, 123—1, 2
venustus, 323, 122—32–34
Finkelnburgia, 298
armanda, 299, 112—28–30
bellatula, 298, 112—22–27
finkelnburgi, 298
Fissuridea, 435, 480
Fistulata, 143
Fistulipora, 255
carbonaria, 255, 96—22, 23
minor, 255
neglecta, 255, 96—21
peculiaris, 271
Flabellammina, 15
alexanderi, 15
saratogaensis, 15, 1—13
Flabellum, 122
cuneiforme, 122, 46—4
cuneiforme lerchi, 122, 46—5
cuneiforme pachyphyllum, 122, 46—8
favonium, 122
merriami, 121
redmondianum, 122, 46—6, 7
Fletcheria, 103
guelphensis, 103, 36—3–5
tubifera, 103
Flexibilia, 177
Flexicalymene, 641, 645
meeki, 645, 272—1, 2
senaria, 645, 272—3–5
Floridina, 273
regularis, 273, 103—23
Floridinella, 273
vicksburgica, 273, 275, 104—5
Flustra, coriacea, 273, 103—26
lanceolata, 267
parallela, 270
savartii, 273
Foersteria, 457
Foraminifera, 12
Forbesiocrinus, 179, 66—14; 67—8
burlingtonensis, 179, 68—20
communis, 179, 68—19
incurvus, 179
multibrachiatus, 179, 68—4
nuntius, 183
pyriformis, 179, 68—13
saffordi, 179, 68—21
thiemi, 181
Fordilla, 660
troyensis, 660, 279—5, 6
Fragilaria, floridana, 301—29
Frankeina, 15
goodlandensis, 15, 1—14
Frondicularia, 32
archiaciana, 32, 6—17
christneri, 32
complanata, 32
Frustulia, lewisiana, 301—21, 22
Fucoides, cauda-galli, 719
encoelioides, 717
harlani, 719
linearis, 234

Fucoides, serra, 69
Fulgur, 501
carica, 501
Fulguroficus, juvenis, 500, 205—13, 14
Fulgurofusus, 507
henekeni, 507, 208—19
quercollis, 507, 208—20
Fungia, coronula, 117
Fusimitra, 509
polita, 509, 210—1
Fusispira, 477
inflatus, 477, 195—19
subbrevis, 477, 195—18
ventricosa, 477
Fusulina, 1, 19, 21, 23
acme, 23, 3—16, 17
cylindrica, 21, 23
eximia, 21, 23, 3—15, 20
girtyi, 21, 3—21, 22
haworthi, 21, 3—18, 19
leei, 21, 3—25, 26
novamexicana, 21, 3—23, 24
sphaerica, 21
Fusulinella, 19, 21
bocki, 21
dakotensis, 21, 3—30–32
euthysepta, 21
iowensis, 21, 3—33, 34
primaeva, 21, 3—37, 38
serotina, 21, 3—35, 36
Fusulinidae, 19
Fusus, 435
averillii, 508, 509
barbarensis, 505
caloosaensis, 507
cinereus, 505
ficulneus, 501
4-costatus, 505
noae, 501
ottonis, 507
quercollis, 507
substriatus, 507
tippana, 507
trabeatus, 500
trivolvus, 501

G

Galateacrinus, 165
allisoni, 165, 64—13
ewersi, 165, 64—14
stevensi, 165, 62—2; 64—15
Galeodea, 500
koureos, 500, 205—29
millsapsi, 500, 205—26–28
Gasconadia, 459
putilla, 459, 186—9–11
Gaspelichas, 647
forillonia, 647, 271—20, 21
Gasterocomidae, 153
Gastrioceras, 573
abichianum, 573
branneri, 573, 235—6–8
listeri, 573, 235—1, 2
russiense, 573
Gastrocaulia, 283
Gastroplites, 589
canadensis, 589, 244—7, 8
Gastropoda, 366, 433
opercula, 447
Gaudryina, 18
bulletta, 18
rugosa, 18
triangularis, 18, 2—10
Gaurocrinus, splendens, 187
Gazacrinidae, 189
Gazacrinus, 189, 70—5
Gazacrinus, inornatus, 189, 72—11
ramifer, 189, 72—10
stellatus, 189, 72—9
Geinitzina, 17
ciscoensis, 18, 2—6
Geisina, 679
arcuata, 679, 285—21, 22
gregaria, 679, 285—20
Geisonoceras, 537, 539
filosum, 537, 219—7, 8
Geisonocerina, 539
wauwatosense, 539, 219—9
Gemmula, 513
Genevievella, 625
neunia, 625, 265—10–12
Gennaeocrinus, 191, 70—14
carinatus, 191, 75—23
eucharis, 191, 75—22
Geodites, bifurcatus, 56, 16—24, 25
carbonarius, 56, 16—20, 22
deflecturus, 56, 16—23
pateus, 56, 16—21, 26
Gephyrea, 234
Geraocrinus, 151
Geronticeras, 473
Gervillia, 389
ensiformis, 389
longispina, 391
montanaensis, 389, 150—11
propleura, 389, 150—21
solenoides, 389
subtortuosa, 389, 150—20
Gervilliopsis, 389
ensiformis, 389, 150—13, 14
Gigantoceras, 555
cancellatum, 555, 228—4
inelegans, 555, 228—3
Gilbertsocrinus, 185, 70—4
calcaratus, 185
fiscellus, 187, 73—4
spinigerus, 187, 73—5
tuberosus, 187, 73—1, 2
typus, 187, 73—3
Gilmocrinus, 169
iowensis, 169, 60—3
Girtycoelia, 56
typica, 56, 17—12, 13
Girtyella, 364
indianensis, 365, 143—24–26
intermedia, 365
turgida, 365, 143—21–23
Girtyoceras, 571
limatum, 571, 234—1–3
meslerianum, 571
Girtyspira, 477
canaliculata, 477, 195—15
minuta, 477, 195—13, 14
pygmaea, 477, 195—11, 12
Girvanella, 715
sp., 302—14
Gissocrinus, 155
arthriticus, 155
lyoni, 155, 55—12
Glabrocingulum, 455
beggi, 455
grayvillense, 455, 184—21–23
wannense, 455, 184—24
Gladiolites, geinitzianus, 75
Glaphyrites, 573
Glaucocrinus, 151
Glauconia, 491
Glauconome, marginalis, 265
Globigerina, 41, 43
bulloides, 41
cretacea, 41, 11—1
Globigerinidae, 12

Globivalvulina, 29
biserialis, 29, 5—15
Globorotalia, 43
fohsi, 43, 11—8
Globorotaliidae, 12
Globotruncana, 43
cretacea, 43, 11—9
Globulina, 32
gibba, 32, 7—2
Glochiceras, 585
fialar, 585, 241—8–10
Glossites, 371
lingualis, 371, 144—28
Glossocrinidae, 157
Glossocrinus, 157
Glossograptus, 65, 75, 22—13
ciliatus, 75, 22—14
quadrimucronatus, 75, 22—12, 13
quadrimucronatus approximatus, 75
quadrimucronatus cornutus, 75, 22—18
whitfieldi, 75, 22—19
Glossopleura, 605, 611
boccar, 611, 258—10
producta, 611, 258—4, 5
Glycymeris, 368, 383
idonea, 383, 148—12, 13
perrini, 383, 148—11
subovata, 383, 148—14, 15
Glyphaspis, 611
capella, 611, 259—14–16
Glyphioceras, 571
Glyphis, 480
Glyphodiscus, stellatus, 301—16
Glyphostomella, 17
triloculina, 17, 1—18, 19
Glyptagnostus, 600
angelini, 600, 251—28
toreuma, 600
Glyptocrinidae, 199
Glyptocrinus, 199, 70—10
decadactylus, 199
dyeri, 199, 73—23
harrisi, 189
lacunosus, 183
nobilis, 187
subnodosus, 183
Glyptocystites, 128
multiporus, 128, 129, 49—1–3
Glyptodesma, 383
erectum, 383, 149—7, 8
Glyptograptus, augustifolius, 73, 22—22
dentatus, 73, 22—4, 5
euglyphus, 73, 22—2
Glyptopleura, 681
alvea, 681, 285—56, 57
bristoli, 681, 285—47
coryelli, 681, 285—52
decacostata, 681, 285—48
henbesti, 681, 285—49, 50
inopinata, 681, 285—53–55
resupinata, 681, 285—51
spinosa, 681, 285—52
Glyptopleurina, 681
bulbosa, 681, 286—9
flexuosa, 681, 286—1–3
iniqua, 681, 285—58, 59
longuronis, 681, 286—4–6
minuta, 673
montifera, 681, 286—8
oehersi, 681, 285—60
Glyptopleuroides, 681
insculptus, 681, 286—22
Glyptopora, 270
sagenella, 270, 102—18
Glyptorthis, 282, 297
bellarugosa, 297, 111—14, 15
Glyptorthis, insculpta, 297, 111—9–13
Gnathodontidae, 245
Gnathodus, 245
macrolobatus, 245, 94—63
mosquensis, 245
pustulosus, 245, 94—59–61
Gnorimocrinus, 177, 67—12
cirrifer, 177, 54—12
Goldius, 653
Gomphoceras, bohemicum, 559
cassinense, 533
indianense, 559
oviforme, 559
Gomphocystites, 129
glans, 129, 48—13, 14
Gondolella, 244
elegantula, 244
merrilli, 245, 94—32–34
Goniasma, 459
lasallensis, 459, 185—21
Goniatites, 571
abichianus, 573
artiensis, 569
bidens, 567
crenistria, 571, 234—4, 5
cyclolobus, 567
falx, 569
gilbertsoni, 575
goniolobus, 571
gorbyi, 567
iowensis, 573
kentuckiensis, 571, 234—9, 10
lutheri, 565
lyoni, 567
marcellensis, 545
missouriensis, 573
orbignyana, 569
oweni parallela, 571
rotatorius, 573
simulator, 565
sobolewskyanus, 577
spiralis, 571
striatus, 573
uniangularis, 567
vanuxemi, 565
Goniobasis, 489
chrysalis, 489, 200—4
osculata, 489
Gonioceras, 553, 555
anceps, 553, 227—15
lambei, 555
Goniocrinus, 158
sculptilis, 158, 57—7
Gonioglyphioceras, 571
Goniograptus, 69
thureaui postremus, 69, 21—2
Gonioloboceras, 571
goniolobum, 571, 234—24, 25
welleri, 573, 234—22, 23
Goniophora, 411
bellula, 411, 413, 164—12
cymbiformis, 411
hamiltonensis, 413, 164—13
perangulata, 413, 164—14
Goniopora, 117
pedunculata, 117
reussiana, 117, 43—16, 17
Goniopygus, zitteli, 226, 88—19, 20; 89—22, 23
Goniospira, 449, 459
filosa, 449
Goniostropha, 459
Gorgonia, retiformis, 65
Gosseletina, 453
spironema, 453, 183—33
subglobosa, 453, 183—32
Gosselettia, 387, 453

Gosselettia, devonica, 387
triquetra, 387, 150—6
Gouldina, 715
Graftonoceras, 543
graftonense, 543, 222—4, 5
Grammysia, 369, 371
arcuata, 371, 144—26, 27
bisulcata, 371, 144—20
communis, 371, 144—23
hannibalensis, 371, 144—18, 19
nodocostata, 371, 144—24, 25
Grammysioidea, 371
alveata, 371, 144—21, 22
princiana, 371
Granocardium, dumosum, 425, 169—7, 8
tenuistriatum, 425, 169—2–4
Graphiocrinus, 171
encrinoides, 171
kingi, 171, 65—18
quatuordecimbrachialis, 175
Graphiodactylus, 681
arkansanus, 681, 285—40–42
granopunctatus, 681, 285—43–46
Graptacme, 521
mediaviense, 523, 214—24, 25
minutistriatum, 523, 214—12, 13
Graptolithus, bicornis, 71
byronoides, 69
flaccidus, 71
foliaceus, 73
geinitzianus, 75
gracilis, 71
hallianus, 65
logani, 69
murchisoni, 70
octobrachiatus, 69
ramosus, 71
Graptoloidea, 65, 69
Graptozoa, 58, 64
Greenops, 647
boothi, 647, 274—11, 12
Griffithides, 645, 647, 651
bufo, 647, 275—9
longiceps, 647
morrowensis, 651
pustulosus, 647, 275—10–12
Griphoporella, 715
Gryphaea, 397
arcuata, 397
convexa, 397, 155—15, 16
corrugata, 397, 155—10, 11
corrugata belviderensis, 397
corrugata hilli, 397
corrugata tucumcarii, 397
mutabilis, 397, 155—12
navia, 397, 155—4, 5
newberryi, 397, 155—19
vesicularis, 397, 155—12
washitaensis, 397, 155—6, 7
wratheri, 397, 155—20, 21
Gryphaeostrea, vomer, 397, 155—1, 2
Gryphites, speluncaria, 393
Grypophyllum, 95
denckmanni, 95
giganteum, 95, 29—24
Gümbelina, 33
globulosa, 33, 8—1
Gümbelitria, 33
cretacea, 33, 8—2
Gunteria, 18
floridana, 18, 2—15–17
Guttulina, 32
communis, 32
problema, 32, 7—1
Gymnotoceras, russelli, 579, 238—15–17
Gypidula, 303, 305
Gypidula, coeymanensis, 305, 115—1–3
lowryi, 305, 115—4, 5
pseudogaleata, 305, 115—6, 7
romingeri, 305, 115—8, 9
Gypsina, 43
rubra, 43, 10—11
Gyroceras, harttii, 545
inelegans, 555
serratum, 547
Gyrodes, 483
abyssina, 483, 198—16, 17
conradi, 483, 198—18, 19
conradiana, 483
crenatus, 483, 198—10–12
depressa, 483, 198—20
expansa, 483, 198—21, 22
petrosa, 483, 198—13–15
supraplicatus, 483, 198—10–12
Gyroidina, 37
girardana, 39, 9—4
orbicularis, 37
Gyronema, 451
historicum, 451, 182—29, 30
pulchellum, 451, 182—34
Gyroporella, 715
maxima, 302—16–19
Gyrotrema, 443

H

Hadrophyllum, 85
aplanatum, 85, 23—29, 30
orbignyi, 85, 23—24, 25
ovale, 85, 23—26–28
Haeretocrinus, 159
Haimesiastraea, 122
conferta, 122, 46—1–3
Haliotis, 435, 473, 480
asininus, 480
lasia, 480, 197—19, 20
Hallia, 93
insignis, 93
vesiculata, 93, 29—19
Hallicystis, 128
imago, 128, 48—15
Halliella, 665
labiosa, 665, 281—15–17
retifera, 665, 281—14
Halloceras, 545
undulatum, 545, 222—14
Hallocrinus, 157
ornatissimus, 157, 57—24
Hallograptus, mucronatus, 75, 22—17
Hallopora, 261
dalei, 261, 99—11
elegantula, 261, 99—6, 7
multitabulata, 261, 99—8–10
ramosa, 261
rugosa, 261, 99—5
Halobia, 393
cordillerana, 393, 153—3
salinarum, 393
superba, 393, 153—2
Halymenites, 717
brongniarti, 717
major, 717, 303—20
Halysiocrinus, 145
dactylus, 145, 147, 55—5
nodosus, 147, 55—9
Halysites, 113
catenularia, 113, 41—4–10
catenulatus, 113
compactus, 113, 41—11–14
gracilis, 113, 41—1–3
labyrinthicus, 113, 41—16, 17
microporus, 113, 41—15
Halysitidae, 105

Hamiltonella, 685
Hamites, 583, 593
attenuatus; 583
fremonti, 583, 240—12
Hamulus, 233
onyx, 233, 92—21–24
squamosus, 233, 92—25
Hantkenina, 41
alabamensis, 41, 11—4
Hapalocrinus, 203
cirrifer, 203, 77—21
gracilis, 203, 77—15
Haploceras, 585
zacatecanum, 585, 241—1, 2
Haplocrinites, 147, 52—2
clio, 147, 56—14
sphaeroideus, 147
Haplocrinitidae, 147
Haplocrinus, elegans, 203
Haplocystis, 131
Haplocystites, 131
Haplocytheridea, 689
blanpiedi, 689, 290—18–22
monmouthensis, 689, 290—1–4
montgomeryensis, 689, 290—12–14
sabinensis, 689, 290—5–8
subovata, 689, 290—26–29
Haplograptus, 69
wisconsinensis, 69, 20—7, 8
Haplophragmium, 15
taylorensis, 15, 1—16
Haplophragmoides, 15
glabra, 15, 1—11
Haplospira, 469
Haplostiche, 13
texana, 13, 1—7, 8
Hapsiphyllum, 87
calcariforme, 87, 24—25–27
Hardouinia, 225
aequoreus, 225, 86—13–15
florealis, 225, 86—10–12
Harpactocarcinus, 701
americanus, 701, 296—5–10
Harpago, tippana, 499
Harpes, primus, 645
Harpoceras, 583
falcifer, 583
propinquum, 583, 240—13, 14
Harrisoceras, 539, 219—16
orthoceroides, 539
Harttina, indianensis, 364
Hastigerina, digitata, 41
Hastigerinella, 41
watersi, 41, 11—7
Hastula, 511
simplex, 513, 210—28, 29
Haustator, 491
pacheoensis, 493, 202—13, 14
whitei, 491, 201—6
Healdia, 682, 685
cuneata, 683, 287—10
limacoidea, 682, 287—4–6
simplex, 682, 287—11
triangularis, 682, 287—3
vinitaensis, 682, 287—1, 2
Hebertella, 281, 299
frankfortensis, 299, 112—52, 53
lineolata, 301
sinuata, 299, 113—14–20
Hederella, 251
canadensis, 251
filiformis, 251, 95—11
Hedstromia, 715
Heilprinia, 505, 507
caloosaensis, 507, 208—15
equalis, 507, 208—14
Helcion, patelliformis, 519
Helcionella, 439
subrugosa, 439, 175—5–10
Helcionopsis, 437
Helenia, 525
bella, 525, 214—37
Helicites, delphinuloides, 453
Helicoceras, 593
annulatum, 593
navarroense, 593, 246—10
rubeyi, 593, 246—11
Helicograpsus, 71
Helicotoma, 467
planulata, 467, 189—9
umbilicata, 467, 189—16, 17
uniangulata, 467, 189—14, 15
Helictostylus, 475
Heliolites, 103
elegans, 103, 34—17
interstinctus, 103, 35—1–5
megastoma, 103, 34—18
Héliolithe, pyriforme, 103
Heliophrentis, 91
alternata, 91
Heliophyllum, 83, 95, 97
halli, 97, 31—8–11
tenuiseptatum, 97
Helix, 521
carinatus, 457
cornea, 519
haliotoides, 481
leidyi, 521, 213—9, 10
margarita, 480
pomatia, 521
vetusta, 521, 213—18, 19
viviparus, 485
Helminthozyga, 463
vermicula, 463, 187—14, 15
Helopora, 265
dendrina, 258
fragilis, 265
harrisi, 265, 100—31, 32
spiniformis, 265, 100—28–30
tenuis, 265
Hemiaster, 225
calvini, 226, 89—7, 8
lacunosus, 219, 225, 87—10–12
parastatus, 225, 87—13–16
riovistae, 226
slocumi, 225, 87—10–12
texanus, 225, 87—7–9
Hemiaulus, claviger, 301—1
Hemicosmites, subglobosus, 129
Hemicystites, 131
carbonarius, 131, 49—14
chapmani, 131, 49—15
devonicus, 131, 49—23
granulatus, 129
parasiticus, 131, 49—13
stellatus, 129
Hemifusus, remondii, 500
Hemigordius, 29
calcareus, 29, 5—10
Hemiphragma, 259
imperfectum, 259, 98—26, 27
tenuimurale, 259, 98—33, 34
whitfieldi, 259, 98—25, 35
Hemipronites, apicalis, 298
Hemithyris, 106—7
Hemitrypa, 264
lata, 263
oculata, 264
proutana, 264, 100—1, 2
Hemizyga, 463
corona, 463
elegans, 463, 187—18

Hemizyga, gracilis, 463
inflata, 463, 187—17
Hercoglossa, 549
ulrichi, 549, 225—7–9
Hercorhynchus, 507
mallaeforme, 507, 208—21, 22
Heritschia, 87, 89
columbica, 87, 25—29
girtyi, 87, 25—12, 13
Hernodia, 251
humifusa, 251, 95—25
Hesperonomia, 297
antelopensis, 297
crassa, 297
planidorsalis, 297, 111—16–20
Hesperorthis, 282, 295, 297, 301, 355, 105—5; 106—3
tricenaria, 297, 111—1–5
Heteractinellida, 56
Heteralosia, 349
slocumi, 349, 135—36, 37
Heteraster, 225
orbignyi, 225
Heterelasma, 364
shumardianum, 364
sp., 364, 143—17–20
Heterocoelia, 56
beedei, 56, 17—4, 5
Heterocrinidae, 149
Heterocrinus, 149, 52—11
constrictus, 149
crassus, 143
geniculatus, 145
heterodactylus, 149, 52—11
simplex, 145
Heterophrentis, 91
nevadensis, 91, 28—13–15
prolifica, 91, 28—7–11
simplex, 91, 28—12
Heteropora, dichotoma, 251
Heterorthina, 106—10
Heterorthis, 355
clytie, 355, 139—27–29
Heterostegina, 33
depressa, 33
ocalana, 33, 7—14
Heterostomella, 18
foveolata, 18, 2—12
Heterotrypa, implicata, 259
Hexacoralla, 81, 83, 115
Hexacrinites, 197
occidentalis, 197, 78—8
Hexacrinitidae, 197
Hexactinellida, 49, 53, 56
delicatula, 56, 16—32–35
Hexactinia, 115
Hexagonaria, 95
anna, 95, 30—19, 20
parvula, 95, 30—13, 14
percarinata, 95, 30—16–18
prisma, 95, 30—11, 12
Hexalonche, microsphaera, 48, 14—24
Hexameroceras, 561
hertzeri, 561, 230—12, 13
Hexastylus, basiporosus, 48, 14—27
Hibbardella, 241, 243
angulata, 241, 93—73
Hindeodella, 240, 241
acuta, 241, 93—47
subtilis, 241
Hindia, 53
fibrosa, 53, 16—1
parva, 53, 16—2–4
Hipparionyx, 343
proximus, 343, 134—6, 7
Hipponicharion, 657
eos, 657
Hipponicharion, minus, 657, 278—14
Hippothoa, delicatula, 250
Hirudinea, 228
Histocrinus, 169, 171
coreyi, 169, 60—22
Holaster, 225
nodulosus, 225
simplex, 225, 226, 86—19–21; 89—10–12
Holcoscaphites, 589
Holectypus, 221
charltoni, 221
limitis, 221, 226, 90—5
planatus, 221, 226, 84—4–9
Hollina, 671
insolens, 671, 282—11, 12
Hollinella, 669
bassleri, 669, 282—14, 15
dentata, 669
emaciata, 669, 282—16–18
kolmodini, 669, 282—1–3
longispina, 669, 282—5, 6
moreyi, 669, 282—4
radlerae, 669, 282—7–9
Holmia, bröggeri, 609
rowei, 611
walcottanus, 619
Holochoanites, 366, 533
Holocystites, 125
Holopea, 469
ampla, 469, 192—3, 4
mima, 473
proutana, 471
pyrene, 469, 192—5, 6
rotunda, 469, 192—7
sweeti, 447
symmetrica, 469, 192—8
Holopella, 461
Holoporella, 276
orbifera, 276, 104—16
Holothuroidea, 123, 227
Holtedahlina, 343
sulcata, 343, 132—30–33
Holteria, 611
problematica, 611, 259—20, 21
Homagnostus, 600
obesus, 600, 251—9, 10
Homalocrinidae, 181
Homalophyllum, 91
calceolum, 93, 28—23, 24
ungula, 91, 28—18–22
Homocrinidae, 145
Homocrinus, 145, 52—7
parvus, 145, 52—7; 53—4
scoparius, 158
Homoeospira, 361
evax, 361, 141—25–27
Homopoda, 599, 655
Homotelus, 639, 647, 654
obtusus, 647, 268—6, 7
ulrichi, 647, 268—8
Homotreta, 289
interrupta, 289, 108—40–43
Homotrypa, 257
curvata, 257
flabellaris, 257, 97—9, 10
minnesotensis, 257, 97—6–8
subramosa, 257, 97—11–13
Honeoyea, 385
erinacea, 385, 149—20, 21
Hopkinsina, 37
danvillensis, 37, 8—20
Hoplites, canadensis, 589
Hoploscaphites, 589
Hormocrinus, 181, 66—2
tennesseensis, 181, 54—6
Hormotoma, 457

Hormotoma, bellicincta, 459, 185—28
gigantea, 459, 185—22
gracilis, 457, 185—12–17
major, 459, 185—25–27
trentonensis, 459, 185—23, 24
whiteavesi, 459, 185—29
Hormotomina, 459
Housia, 625
canadensis, 625, 265—7, 8
varro, 625, 265—9
Hudsonaster, 211
matutinus, 211, 80—5
narrawayi, 211, 80—6
Hudsonospongia, 53
cyclostoma, 53, 15—10–12
Huenella, 301
texana, 301, 114—15
Hughmilleria, 709
shawangunk, 709, 299—5, 6
socialis, 709, 299—11
Hungaia, billingsi, 647
Huronia, 553
bigsbyi, 553, 227—8
bigsbyi intermedia, 553, 227—4
inflecta, 553
vertebralis, 553, 227—7
Huroniella, 553
inflecta, 553, 227—5, 6
Hustedia, 363
hessensis, 363, 141—46–48
mormoni, 363, 141—43–45
Hyalostella, diabola, 56, 16—16
Hyattidina, 331
congesta, 331, 127—1–4
Hybochilocrinus, 147
americanus, 147, 56—2
rowleyi, 147, 56—1
Hybocrinidae, 151
Hybocrinus, 151, 52—3
conicus, 151, 53—22
tumidus, 151, 53—3
Hybocystites, 151, 52—3
eldonensis, 151, 53—1
problematicus, 151
Hydnoceras, 55
tuberosum, 55, 16—19
Hydractinia, 59
Hydreionocrinus, acanthophorus, 165
crassidiscus, 163
daileyi, 163
noduliferus, 161
spinosus, 167
subsinuatus, 163
Hydriocrinus, 159
Hydrocorallinae, 58
Hydrotribulus, 503
nodosus, 503, 207—1, 2
Hydrozoa, 58
Hylodecrinus, 161
asper, 161, 60—4
sculptus, 161, 60—2
Hymenocarina, 655
Hymenocaris, 655
perfecta, 655, 277—1
vermicauda, 655
Hyolithellus, 77, 525
micans, 525, 214—32–36
Hyolithes, 523, 525
acadicus, 525, 215—15
acutus, 523
americanus, 525, 215—1–6
baconi, 525, 215—42–44
billingsi, 525, 215—7–9
communis, 525, 215—34–41
danianus, 525, 215—14
decipiens, 525, 215—50–52
Hyolithes, impar, 525, 215—10–13
intermedius, 525
neapolis, 525, 215—47–49
primordialis, 525, 215—45, 46
princeps, 525, 215—16–20
quadricostatus, 525, 215—24–26
shaleri, 525, 215—31–33
similis, 525, 215—21–23
terranovicus, 525, 215—27–30
Hyolithidae, 77
Hyperammina, vagans, 15
Hyperamminella, elegans, 13
Hyperamminoides, 13
elegans, 13, 1—3, 4
Hypergonia, 459
Hyphantozyga, 463
gracilis, 463, 187—16
Hypophylloceras, onoense, 581, 239—19
Hypothyridina, 313
emmonsi, 315, 120—1–4
venustula, 315, 120—5–7
Hypselentoma, 453
Hypseloconus, 439
elongatus, 439, 175—16
recurvus, 439, 175—14, 15
recurvus elongatus, 439
Hypselocrinus, 169
arcanus, 169, 58—17
douglassi, 169, 60—8
hoveyi, 169, 60—21
lasallensis, 169, 57—17
maccabei, 169, 60—9
macoupinensis, 169, 57—19
sansabensis, 169, 60—10
Hypsocrinus, 147
Hystricurus, 647
conicus, 647, 267—27
missouriensis, 647, 267—28, 29

I

Ichthyocrinidae, 183
Ichthyocrinus, 183, 66—11, 15
corbis, 183, 68—11
devonicus, 183, 68—17
laevis, 183, 68—3
nobilis, 177
subangularis, 183, 54—5
Ichthyosarcolites, 421
Icriodus, 235, 245
alternatus, 245
curvatus, 245, 94—62
expansus, 245, 94—63
latericrescens, 245, 94—64
symmetricus, 245, 94—65
Idahoia, 625
hamulus, 625, 265—18, 19
serapio, 625, 265—20, 21
wisconsensis, 625, 265—17
Iddingsia, 627
similis, 627, 265—15, 16
Idiognathodus, 246
claviformis, 246
delicatus, 246, 94—56–58
Idiohamites, fremonti, 583, 240—12
Idiostroma, 63
Idiostromidae, 63
Idmonea, triforata, 251, 95—23, 24
Idoceras, 585
viverose, 585, 242—6, 7
Idonearca, 379
antrosa, 379, 147—9
carolinensis, 379, 147—4, 5
truncata, 379, 147—3
vulgaris, 379, 147—7, 8
Igoceras, 473
Ildraites, 231

Ildraites, bipennis, 231, 91—76
duplex, 231, 91—74, 75
Ilionia, ohioensis, 423, 168—13
Illaenurus, 627
albertensis, 627, 260—15
quadratus, 627, 260—16–19
Illaenus, 639, 647, 654
americanus, 647, 268—16–18
Imitoceras, 573
grahamense, 573, 234—18, 19
Inadunata, 143
monocyclica, 143
Inarticulata, 281, 283
Indiana, 657
faba, 657, 278—8–12
lippa, 657
Infusoria, 11
Inocaulis, 67
plumulosus, 67, 20—9
ramulosus, 67, 20—10
Inoceramus, 389, 395
altus, 389
barabina, 389, 151—17, 18
chemungensis, 387
comancheanus, 389, 151—11
cuvier, 389
deformis, 389, 151—16
dimidius, 389, 151—3, 4
fragilis, 389, 151—6
gilberti, 389, 151—7, 8
labiatus, 389, 151—15
sagensis, 389, 151—12
simpsoni, 389, 151—5
umbonatus, 389, 151—13, 14
unabundus, 389, 151—9, 10
undulato-plicatus, 389, 151—2
Insecta, 599, 701
Institella, 351
leonardensis, 351, 138—3–5
Intrapora, 269
puteolata, 269, 101—27
Intricaria, reticulata, 261
Introsiphonata, 366, 565
Iocrinidae, 143
Iocrinus, 143, 155, 52—15
crassus, 143, 52—15; 53—2
subcrassus, 143, 53—10, 11
Iphidea, sculptilis, 287
Irvingella, 623, 627
major, 627, 265—25
media, 627, 265—26, 27
Ischadites, 57
iowensis, 57, 17—27, 28
Ischnochiton, 527
magdalenensis, 527, 216—17–21
Ischyrodonta, 381, 411
truncata, 381, 148—3, 4
unionoidea, 381, 148—1, 2
Isocardia, 425
cor, 425
fraterna, 425, 169—18, 19
unioniformis, 373
Isocardiacea, 425
Isochilina, 664
jonesi, 664, 280—14–16
ottawa, 664, 280—13
Isodonta, 366, 401
Isonema, 471
depressum, 471
humile, 471, 193—24
Isorophus, 129
cincinnatiensis, 131, 49—8
Isorthis, 357
arcuaria, 357, 139—51–53
perelegans, 357, 139—50
szajnochai, 357
Isoteloides, 647
canalis, 647, 268—9, 10
Isotelus, 647
bearsi, 654
brachycephalus, 647, 268—19
gigas, 1, 647, 268—2, 3
iowensis, 647, 268—1
rectifrons, 639
Isotomocrinus, 149, 52—11
typus, 149, 52—11
Iteacrinus, 158

J

Jaekelocystis, 129
hartleyi, 129, 48—17–19
Jahnnites, 589
Jania, 715
Janira, 405
niternudia, 405
Joleaudella, 443
Jonesella, 667
crepidiformis, 667, 281—21–23
Jonesina, 679
bolliaformis, 679, 285—28–31
carbonifera, 681, 285—32–34
craterigera, 679, 285—24–27
minnekahtensis, 681, 285—35–39
Juresania, 281, 350
nebrascensis, 350, 137—1–3
symmetrica, 350, 137—4, 5
Juvavites, 581
brockensis, 581, 239—9–11

K

Kainella, 647
billingsi, 649, 274—9
Kallimorphocrinus, 147, 52—4
astrus, 147, 149, 56—3
expansus, 149, 56—4
indianensis, 149, 56—5
puteatus, 149, 56—6
Kanastephanus, 585
crickmayi, 585, 241—13, 14
Kangarina, 689
Kaskia, 649
chesterensis, 649, 275—29–33
Kellettina, 671, 673
montosa, 673
robusta, 673, 283—11
Kerakephalichas, 649
bicornis, 649, 270—11, 12
rhinoceras, 649, 270—5
Keratophytes, dubius, 264
Kingena, 365
wacoensis, 365, 143—32–34
Kingstonia, 627
apion, 627, 263—28–30
walcotti, 627, 263—1, 2
Kionoceras, 539
austini, 541, 220—13
cancellatum, 539, 220—9
Kirkbya, 671
canyonensis, 671, 282—22–25
clarocarinata, 671, 282—21
lindahli, 673
lindahli arkansana, 681
marginata, 671, 282—20
regularia, 671, 282—19
Kirkbyella, 671
bellipuncta, 671, 282—43, 44
truncata, 671, 282—45, 46
typa, 671, 282—47
Kirkoceras, 533
arcuatum, 533, 217—9
Kiwetinokia, 53
utahensis, 53, 16—11

Kloedenella, 677, 679
gibberosa, 677, 284—19, 20
macer, 677, 284—25, 26
nitida, 677, 284—21, 27–30
pennsylvanica, 677, 284—22–24
Kloedenia, 675, 677
normalis, 675, 283—34–36
pennsylvanica, 677
sussexensis, 675, 282—10; 283—40
ventralis, 675, 283—39
Kobayashiella, 439
Kochaspis, 611
coosensis, 611, 257—12, 13
dispar, 611, 257—17–19
liliana, 611, 257—16
Kochiella, 613
mansfieldi, 613, 253—7, 8
tuberculata, 613
Kochina, 613
americana, 613, 253—14, 15
Kochoceras, 551
cuneiforme, 551, 226—8, 9
Koenenia, emarginata, 377, 146—24
Kokenia, 441
Kokenospira, 441
Koninkites, 577
Kootenia, 613
convoluta, 613, 257—1–4
currieri, 613, 257—5
dawsoni, 613, 257—6
marcoui, 613, 257—10, 11
Kophinoceras, 545
Kormagnostus, 600
simplex, 600, 251—25–27
Kossmatia, 587
victoris, 587, 243—1–3
Krausella, 682
arcuata, 682, 286—51–55
inaequalis, 682, 286—48–50
Krithe, 691
hiwanneensis, 691, 291—33–35
perattica, 691, 291—36, 37
Kutorgina, 284, 293
cingulata, 293, 110—1–3
Kyammodes, 677
swartzi, 677, 284—40
tricornis, 677, 284—38, 39
whidbornei, 677
Kyphopyxa, 32
christneri, 32, 6—18

L

Labechia, 63
subcylindrica, 63, 19—14, 15
Labechiidae, 63
Lacinia, 501
alveata, 501, 205—22
Ladogiella, 106—12
Laevidentalium, 521
caduloide, 523, 214—14; 15
martini, 521, 214—16
pauperculum, 523, 214—7
Lagena, 32
hexagona, 32, 6—19
sulcata, 32
Lageniocrinus, 154
Lamarckina, 37
ripleyensis, 37, 9—2
Lambeoceras, 555
confertum, 555, 227—12
lambei, 555, 227—11
Lambeophyllum, 93
profundum, 93, 29—3–5
Lamellibranchiata, 367
Lampsilis, farri, 399, 158—4
Lampterocrinidae, 187
Lampterocrinus, 187, 70—2
roemeri, 187, 72—17
tennesseensis, 187, 72—18
Lapparia, 508
dumosa, 508, 209—12, 13
Laqueus, 105—1, 3
Larraria, 715
Larvia, davisi, 302—24–29
Larviformia, 143
Lasanocrinus, 163
cornutus, 163, 62—6, 63—15
daileyi, 163, 63—14
Lasiocrinus, 158, 52—5
expressus, 158, 53—14
scoparius, 158, 52—5; 53—15
Lasiograptus, 75
costatus, 75
mucronatus, 75, 22—17
Latirus, 507
aurantiacus, 507
filicatus, 508, 208—13
floridanus, 508, 208—12
Latischisma, 457
Laudonocrinus, 163, 165
catillus, 165, 64—9
subsinuatus, 165, 62–10; 64—10
Laurelocrinus, 200
paulensis, 200, 73—20
wilsoni, 200, 73—19
Leaia, 660
leidyi, 660
tricarinata, 660, 279—30, 31
Lebetocrinus, 159
Lebetodiscus, chapmani, 131, 49—15
Lecanocrinidae, 181
Lecanocrinus, 181, 66—6, 13
macropetalus, 181, 68—15
pisiformis, 181, 54—2
pusillus, 181, 54—1
Lecanospira, 4, 467
compacta, 467, 189—32–34
Lechritrochoceras, 543
desplainense, 545, 222—13
Lecythocrinidae, 154
Lecythiocrinus, 154
adamsi, 154, 53—20
olliculaeformis, 154, 53—21
Leda, 377
Legumen, 429
ellipticum, 429, 171—12
Leiocidaris, 219
hemigranosus, 219, 226, 83—16; 89—1–3
imperialis, 219
Leiopteria, 383
dekayi, 383, 149—5
laevis, 385, 149—2, 3
rafinesquii, 385, 149—4
subplana, 385, 149—6
Leiorhynchus, 311, 313
carboniferum, 313, 119—14–16
castaneum, 313, 119—10–13
laura, 313, 119—5–7
limitare, 313, 119—42
mesacostale, 313, 119—4
multicostum, 313, 119—8, 9
rockymontanum, 313, 119—17–19
Leiosoecia, 251
parvicella, 251, 96—9
Leiostegium, 649
puteatum, 649, 267—20–22
quadratum, 649, 267—16
Lemintina, 491
cuvieri, 491
granifera, 491, 201—1, 2
virginica, 491, 201—3
Lemmatophora, 298—11

Lenticulina, 31
navicula, 31, 6—4
rotulata, 31
Lenticulites, complanata, 33
Leonardophyllum, 89
acus, 89, 26—1–3
distinctum, 89, 25—26–28
Leonaspis, 651
Leopeplum, leioderma, 509, 209—14, 15
Leopoldia, 587, 589
victoriensis, 589, 243—6, 7
Lepas, 695
Leperditella, 664
rex, 664, 280—31
tumida, 664, 280—32–34
Leperditia, 664
alta, 664, 280—9–12
brittanica, 664
crepidiformis, 66?
fabulites, 664, 280—1–4
inflata, 664
ottawa, 664
rex, 664
scalaris, 664, 280—5–8
Lepetopsis, 469
haworthi, 469, 191—11
levetti, 469, 191—3, 4
parrishi, 469, 192—1, 2
Lepidesthes, 219
coreyi, 219, 82—16
Lepidocoleus, 695
sarlei, 695, 293—32–35
Lepidocyclina, 45
claibornensis, 45, 13—14, 15
favosa, 47, 12—19, 20
fragilis, 45, 13—11, 12
gardnerae, 45, 13—17, 18
mantelli, 45, 13—16
morganopsis, 47
mortoni, 45, 13—1–3
parvula, 45, 13—7, 8
supera, 43, 13—4, 5
texana, 47, 13—6
undosa, 47, 13—13
yurnagunensis, 47, 13—9, 10
Lepidodiscus, 131
alleganius, 131
pileus, 131
squamosus, 131, 49—21
Lepidorbitoides, 45
minima, 45, 12—11
rooki, 45, 12—1, 2
Lepocrinites, 128
gebhardi, 128, 49—5, 6
Lepralia, punctata, 275
Leptaena, 282, 341
analoga, 343, 132—28, 29
concava, 343
nucleata, 347
planumbona, 337
profunda, 339
rhomboidalis, 1, 343, 132—16–22
richmondensis, 343, 132—23–25
sericea, 335
stephani, 339
subquadrata, 337
sulcata, 343
unicostata, 343, 132—26, 27
Leptaenisca, 343
concava, 343, 132—34, 35
Leptalosia, 349
radicans, 349, 135—34, 35
scintilla, 349, 135—41
Leptarbacia, arguta, 226, 88—15–18
Leptellina, 335
tennesseensis, 335, 128—21–24
Leptobolus, 285
lepis, 285, 107—15–17
Leptochirognathus, 237
coalescens, 237, 93—1
quadrata, 237, 93—11
semifloralis, 237, 93—13
Leptocoelia, 319
concava, 319
flabellites, 319, 121—26–28
imbricata, 319
Leptodesma, 385
agassizi, 385, 149—14
potens, 385
rogersi, 385, 149—13
Leptodus, 345
americanus, 345, 134—30, 31
richthofeni, 345
Leptograptus, 71
annectans, 71, 21—24
Leptomitus, 51
lineatus, 51, 15—1, 2
zitteli, 51
Leptoptygma, 479
simplex, 479, 196—17, 18
virgatum, 479, 196—19
Leptosolen, 429
biplicata, 429, 171—10, 11
Leptostrophia, 341
camerata, 341
magnifica, 341, 131—18, 19
Leptozyga, 461
minuta, 461, 187—10
Leurocycloceras, 539
junciforme, 539, 220—2
niagarense, 539, 220—3
raymondi, 539, 220—4
Leurorthoceras, 551
hanseni, 551, 226—4, 5
Levenea, 353
subcarinata, 353, 138—21–23
Levifusus, 500
trabeatus, 501, 205—20
Lichas, 649
cucullus, 637
eriopis, 645
ferrisi, 649, 270—17, 18
grandis, 654
gryps, 641
laevis, 654
Lichenalia, 249, 271
concentrica, 255, 271, 103—4
Lichenocrinus, 151
Lichenopora, 251
grignonensis, 251, 95—29
turbinata, 251
Ligonodina, 241
delicata, 241, 93—74
pectinata, 241, 93—75
Liljevallia, 343
adnascens, 343, 132—41, 42
gothlandica, 343
Lima, 368, 407
macroptera, 383
occidentalis, 409, 163—14
reticulata, 409, 163—13
retifera, 409, 163—10
utahensis, 409, 163—12
wacoensis, 409, 163—11
Limacina, 517
elevata, 517, 213—22–24
Limnaea, tenuicostata, 519
Limoptera, 383
macroptera, 383, 149—1
Limulus, 707
polyphemus, 707, 300—15–17
Lindstroemella, 291

Lindstroemella, aspidium, 291, 109—27
Linearia, 429
metastriata, 429, 171—3, 4
multicostata, 429, 171—5
Lingula, 281, 285
cobourgensis, 285
concentrica, 291
cuneata, 285
davisi, 285
elderi, 285
iowensis, 285
melie, 285
nebrascensis, 285
pinnaformis, 285
polita, 285
punctata, 285
reevii, 285, 107—20
spatulata, 285
subspatulata, 285
Lingulasma, 285
schucherti, 285, 107—25-28
Lingulella, 285, 105—2
ampla, 285
similis, 285, 107—3-5
Lingulepis, 285
pinnaformis, 285, 107—1, 2
walcotti, 285, 107—6, 7
Lingulina, 32
carinata, 32
taylorana, 32, 6—10
tuberosa, 37
Linnarssonella, 289
girtyi, 289, 109—4-8
Linocrinus, 167
arboreus, 167, 59—5
asper, 167, 64—19
compactus, 167, 64—23
penicillus, 167, 64—20
praemorsus, 167, 64—22
scobina, 167, 64—24
wachsmuthi, 167, 59—3
Linoproductus, 351
oklahomae, 351, 138—1, 2
ovatus, 351, 137—32-34
prattenianus, 351, 137—31
Linthia, 226
insignis, 226
variabilis, 226, 87—17-21
Linuparus, 699
canadensis, 699, 295—1
Lioclema, 259
gracillimum, 259, 98—23, 24
Lioderma, 508
Liomphalus, 465
Liopeplum, 508
Liopistha, 415
protexta, 415, 165—28
Liospira, 451
americanum, 453
micula, 453, 183—1-6
progne, 453, 183—13-15
vitruvia, 453, 183—9-12
Liostracus, 605
aculeatus, 605
Liparocrinus, 157
Liroceras, 545
liratum, 545, 223—8-10
missouriense, 545
Lisania, breviloba, 631
Lispodesthes, nuptialis, 499, 204—10, 11
Lissochonetes, 347
geinitzianus, 347, 135—13, 14
Lissocoelia, 51
ramosa, 51, 15—13
Lithistida, 49, 51
Lithoconus, sauridens, 513, 211—1, 2
Lithodendron, dichotomum, 119
trichotomum, 117
Lithodesmium, cornigerum, 301—15
Lithodomus, 413
Lithophaga, 413
carolinensis, 413, 164—25-27
mytuloides, 413
Lithophyllum, 715
Lithoporella, 715
Lithostrotion, 89
proliferum, 89, 26—6-8
striatum, 89
whitneyi, 89, 26—4, 5
Lithostrotionella, 83, 89
americana, 89, 26—13, 14
castelnaui, 89, 26—9-12
hemisphaerica, 89, 26—15-17
unicum, 89
Lithothamnium, 715
isthmi, 302—33
Litiopsis, 469
Littorina, 489
berryi, 489, 200—11, 12
littoralis, 489
scutulata, 489, 200—8-10
Lituites, angulatum, 541
bickmoreanus, 543
graftonensis, 543
seelyi, 541
Lituola, 17
nautiloidea, 17
taylorensis, 17, 1—15
Lobobactrites, 565
clavus, 565, 231—11
Loculipora, 263
perforata, 263, 99—33
Loganellus, nitidus, 625
Loganograptus, 69
logani, 69, 21—3
Logocrinus, 169
geniculatus, 169, 58—1
infundibuliformis, 169, 58—13
Lomatoceras, priodon, 75
Lonchocephalus, 627
chippewaensis, 627, 265—30
minor, 627, 265—22-24
Lonchodina, 243
pulchra, 243, 94—22
separata, 243, 94—23
typicalis, 243
Lonchodomas, 649
halli, 649, 267—10-13
normalis, 649, 267—14, 15
Longispina, 347
emmetensis, 347, 135—1, 2
Lonsdaleia, 89
indica, 89
Lophamplexus, 87
eliasi, 87, 25—14-19
Lophophyllidium, 83, 87
dunbari, 87, 25—8-11
profundum, 87
proliferum, 87, 25—1-7
Lophophyllum, 87
Lophosmilia, 121
texana, 121, 45—27-29
Lophospira, 449
acuminatus, 451, 182—23
liratus, 449, 182—24
medialis, 451, 182—16-19
milleri, 449, 182—1, 2
oweni, 449, 182—10, 11
perangulatus, 449, 182—3-5
rectistriatus, 449, 182—6, 7
serrulatus, 449, 182—12, 13
solutus, 451, 182—25-27

Lophospira, sumnerensis, 449, 182—14, 15
wisconsinensis, 449, 182—8, 9
Loricula, 695
canadensis, 695, 293—7, 8
pulchella, 695
Loriolia, ornata, 226, 89—17–19
texana, 226, 89—13, 14
Lovenechinus, 217
missouriensis, 217, 82—20
Loxobucania, 445
halli, 445, 179—11–14
lindsleyi, 445, 179—9, 10
punctifrons, 445, 179—15
Loxoconcha, 691
claibornensis, 691, 291—27, 28
fletcheri, 691, 291—32
perdecora, 691
woodwardensis, 691, 291—29–31
Loxodus, 241
bransoni, 241, 93—45, 46
Loxonema, 435, 461
attenuata semicostata, 461
bellatulum, 469
delphicola, 461, 186—17, 18
hamiltoniae, 461, 186—16
leda, 461, 186—15
murrayanum, 461, 186—22
noe, 461, 186—19, 20
sulcatum, 461
terebra, 461, 186—21
Loxoplocus, 449
acuminatus, 451, 182—23
bowdeni, 449, 182—20–22
liratus, 449, 182—24
medialis, 451, 182—16–19
milleri, 449, 182—1, 2
oweni, 449, 182—10, 11
perangulatus, 449, 182—3–5
rectistriatus, 449, 182—6, 7
serrulatus, 449, 182—12, 13
solutus, 451, 182—25–27
sumnerensis, 449, 182—14, 15
wisconsinensis, 449, 182—8, 9
Loxopteria, 385
corrugata, 385, 149—17
dispar, 385, 149—18, 19
Loxostoma, 35
plaitum, 37, 8—18
subrostratum, 35
Lucina, 423
acutilineata, 423, 168—25
curta, 423, 168—26, 27
occidentalis, 423, 168—22, 23
smithi, 423, 168—24
subundata, 423, 168—28
uhleri, 423, 168—26, 27
whitei, 423, 168—24
Lucinacea, 421
Lucinoma, 423
acutilineata, 423, 168—25
Lumbriconereites, 229
armatus, 229, 91—37
austini, 229, 91—40
basalis, 229, 91—35
cameratus, 229, 91—39
cooperi, 229, 91—41, 42
dactylodus, 229, 91—38
deperditus, 229
expansus, 229, 91—34
hibbardi, 229, 91—43, 44
superbus, 229, 91—45
triangularis, 229, 91—33
webbi, 229, 91—36
Lunatia, 483
halli, 485, 198—29–32
lewisii, 485, 198—28
Lunatia, pedernalis, 483, 198—33
subcrassa, 485, 198—26, 27
Lunulacardium, 385
curtum, 385, 149—15
fragile, 385, 149—16
semistriatum, 385
Lunulites, conica, 273
umbellata, 273
Luvula, 689
Lyellia, 103
americana, 103, 35—9–11
Lyonicrinus, 201, 203
bacca, 201, 77—19
Lyramula, 11
furcula, 11, 14—7, 8
Lyria, 508
pycnopleura, 508, 209—1, 2
Lyriocrinus, 185
melissa, 185, 72—28
Lyriopecten, 403
orbiculatus, 403, 160—9, 10
tricostatus, 403, 160—13
Lyrodesma, 399
major, 401, 159—6, 7
planum, 399
Lyrogoniatites, 571
newsomi, 571, 234—13, 14
newsomi georgiensis, 571, 234—15–17
Lyropecten, 403
estrellanus, 407, 162—3, 4
estrellanus terminus, 407, 161—20
jeffersonius, 407, 162—11
jeffersonius septenarius, 407, 162—7
madisonius, 407, 162—6
Lyropora, 264
quincuncialis, 264, 100—23, 24
subquadrans, 264
Lysocystites, 129
nodosus, 129, 49—4–7
Lytoceras, 581
batesi, 581, 239—17, 18
Lytospira, 465
priscus, 465, 189—1, 2
præclivis, 465, 189—3, 4
subrotundus, 465, 189—7, 8
undulatus, 465, 189—5, 6

M

Machairodus, 239
romboideus, 239
Maclurea, 467
striatus, 449
Maclurina, 467
Macluritella, 469
stantoni, 469, 190—15, 16
Maclurites, 467
logani, 469, 190—7–9, 11–14
magnus, 467, 190—1–6
manitobensis, 469, 190—10
Macoma, 429
nasuta, 429, 171—15
tenera, 429
Macraster, 225
elegans, 225, 226, 88—1
nodopyga, 225, 226, 89—15, 16
texanus, 225
washitae, 225, 226, 88—9, 10
Macrocallista, horni, 427, 170—20
Macrocheilus, 479
Macrochilina, 479
Macrocrinus, 197
jucundus, 197, 76—18
konincki, 197, 76—17
verneuilianus, 197, 76—19
Macrocypris, 683
graysonensis, 683, 287—67, 68

Macrocypris, menardensis, 683, 287—69, 70
Macrocytherina, 689
Macrodon, 379
rugosus, 379
Macronotella, 664
rugosa, 665, 280—41
scofieldi, 665, 280—42–44
Macropneustes, 226
mortoni, 226, 90—1–4
Macroporella, 715
Macrostylocrinus, 200, 70—15
fasciatus, 200, 74—7
granulosus, 200, 74—6
laevis, 200, 74—4
ornatus, 200, 74—13
striatus, 200, 74—5
Mactra, 368, 431
albaria, 431, 171—16
ashburneri, 431
clathrodon, 431, 171—17, 18
Mactracea, 431
Madrepora, centralis, 121
palmata, 119
Madreporaria, 105
Madreporites, articulatus, 99
Maeandrostia, 56
kansasensis, 56, 17—10, 11
Magellania, 283
Malacostraca, 599, 695, 298—10
Maladia, 627
americana, 627, 265—28, 29
Malaiocrinus, 157
Malocystites, 125
barrandi, 125
murchisoni, 125, 47—12, 13
Malonophyllum, 87
kansasense, 87, 24—28–31
texanum, 87
Mambrinia, koureos, 500, 205—29
Mamillopora, 276
cupula, 276
tuberosa, 276, 104—12, 13
Mandaloceras, 559
hawthornense, 559, 229—12
scrinium, 559, 229—10, 11
Mangelia, 514
harveyensis, 514, 211—16
hexagona, 514, 211—18, 19
parva, 514, 211—17
striolata, 514
Manticoceras, 565
simulator, 565, 231—6–8
sinuosum, 565, 231—16, 17
Maragnicrinus, 157
portlandicus, 157, 57—12
Margarita, 480
Margarites, 480
abyssina, 480, 197—7–9
mudgeana, 480, 197—6
ornatissima, 480, 197—10
Marginella, 509
denticulata, 509, 210—5
limatula, 509, 210—7
minuta, 509, 210—8
virginiana, 509, 210—6
Marginicinctus, 349
marginicinctus, 349, 135—49–51
Marginifera, 351
adairensis, 351, 137—20–23
lasallensis, 351, 137—16–18
muricatina, 351, 137—24–26
splendens, 351, 137—19
typica, 351
wabashensis, 351, 137—27, 28
Marginirugus, 350
magnus, 350, 135—52, 53
Marginulina, 31
bullata, 31, 6—6
glabra, 31
Mariacrinus, warreni, 199
Marjumia, 613
typa, 613, 258—17
Marsipograptus, 67
bullatus, 67
percensis, 67, 20—23
Marsupiocrinidae, 201, 71—16
Marsupiocrinites, coelatus, 201
dactylus, 185
Marsupiocrinus, 201, 71—16
rosaeformis, 201, 77—25
striatissimus, 201, 77—24
Marsupites, 207
americanus, 207, 79—26
testudinarius, 207
Marsupitidae, 207
Martiniopsis, 329
inflata, 329
kirki, 329, 126—36, 37
laevis, 329, 126—44–46
maia, 329, 126—34, 35
Maryvillia, 627
arion, 627, 265—31, 32
Massilina, 27
pratti, 27, 5—5
Mastigobolbina, 675
lata, 675, 283—46
modesta, 675, 283—47, 48
typus, 675, 283—49, 50
Mastigophora, 11
Mataxa, 515
elegans, 515, 211—33, 34
Matherella, 439
saratogensis, 439, 175—20
Mazapilites, 585
symonensis, 585, 241—3–5
Mazonia, 709
woodiana, 709, 300—6–9
Mcewanella, 301
lineolata, 301
raymondi, 301, 112—54–58
Mcqueenoceras, 533
jeffersonense, 533, 217—12
Medlicottia, 569
whitneyi, 569, 233—8, 9
Meekella, 345
striatocostata, 345, 133—9–16
Meekoceras, 577
gracilitatis, 577, 237—9, 10
Meekopora, 249, 255
clausa, 255, 96—30–32
eximia, 255
Meekospira, 477
minuta, 477, 195—9
peracuta, 477, 195—20
planilateralis, 477, 195—6–8
subconica, 477, 195—10
Megacystites, 125
alternatus, 125, 47—2
cylindricus, 125, 47—1
Megaglossoceras, 545
montgomeryense, 545, 223—6, 7
Megalaspis, 655
belemnurus, 654
Megalomus, 381
canadensis, 381, 147—10–12
Megambonia, 381
cardiiformis, 381
lamellosa, 381, 147—23
Meganteris, suessana, 363
Megastrophia, 339, 341
concava, 339, 130—25; 131—1–4
hemisphaerica, 339

Megistocrinus, 191, 71—3
concavus, 191, 75—12
evansii, 191, 75—11
nobilis, 191, 75—9
nodosus, 191, 75—10
Melania, 489
amarula, 489
humerosa, 489
insculpta, 489, 200—1
wyomingensis, 489, 200—2, 3
Melbacrinus, 159
Mellita, 223
caroliniana, 223, 86—4–6
Melobesia, 715
Melocrinites, 199, 200
bainbridgensis, 200, 74—9
hieroglyphicus, 200
nodosus, 200, 74—10
Melocrinitidae, 199
Melonechinus, 217
multiporus, 219, 83—1–3
Melonites, 217
danae, 217
multipora, 217
Melonopsis, 217
Melosira, clavigera, 301—12
granulata, 301—26, 30
Membranipora, lacroixii, 271
magnilabris, 275
Membraniporae, 271
Membraniporina, 271
Mendacella, 353
uberis, 355, 138—39–42
Menomonia, 627
avitas, 627, 265—33, 34
buttsi, 627, 265—35
calymenoides, 627, 265—36
semele, 627, 265—37, 38
Mercenaria, 427
mercenaria, 427, 170—8, 9; 173—10, 11
Meretrix, 427
cretacea, 427, 170—19
eufaulensis, 427, 170—11, 12
tippana, 427, 170—17, 18
umzambiensis, 427
Meretrosulus, gracilis, 301—4
Merista, 331
tennesseensis, 331, 126—56–59
typa, 331, 126—60–62
Meristella, 331, 333, 106—18
arcuata, 333, 127—20–22
atoka, 331, 127—17–19
barrisi, 333, 127—16
maria, 331
nasuta, 333, 127—26, 27
robertsensis, 333, 127—23–25
Meristina, 331
maria, 331, 127—12–15
Merocrinidae, 155
Merocrinus, 155
corroboratus, 155, 53—17
typus, 155, 53—16
Merostomata, 599, 705
Mesalia, 495
martinezensis, 495, 203—5
seratim-granulata, 495, 203—3, 4
vetusta, 495, 203—6
Mesocena, 11
elliptica, 11, 14—18
Mesocoelia, 457
Mesogastropoda, 366, 475
Mesolobus, 347
mesolobus, 347, 135—6–8
Mesopalaeaster, 211
shafferi, 211, 80—7, 8
Mesophyllum, 101, 715
Mesophyllum, defectum, 101
lonense, 101, 33—14, 15
vesiculosum, 101, 33—16, 17
Mesotrypa, 257
quebecensis, 257, 97—14, 15
Mespilocrinus, 181, 66—7
blairi, 181, 68—12
forbesianus, 181
konincki, 181, 68—18
Metablastus, 135
bipyramidalis, 135, 51—7
lineatus, 135, 51—8
Metacoceras, 547
cavatiforme, 547, 224—12, 13
sangamonense, 547, 224—3, 4
sculptile, 547
Metaconularia, 77, 79
ulrichi, 79, 22—31
Metacypris, 693
cordata, 693
pahasapensis, 693, 291—43–46
whitei, 693, 291—38–42
Metalegoceras, 573
schucherti, 573, 235—22, 23
Metalonchodina, 243
bidentata, 243, 94—20
Metaplasia, 329
pyxidata, 329, 126—40–43
Metaspyroceras, 541
ruedemanni, 541, 220—11, 12
Metatirolites, 579
foliaceus, 579, 238—8–10
Metengonoceras, 593, 595
inscriptum, 593, 248—4–6
Meteoraspis, 627
metra, 629, 265—42
Metichthyocrinus, 183, 66—12
burlingtonensis, 183, 68—6
clarkensis, 183, 68—9
Metoicoceras, 591
swallovi, 591, 245—6, 7
whitei, 591, 245—8–10
Metoptoma, cornutaforme, 437
rugosum, 439, 175—5–10
Metracolposa, 275
robusta, 275, 104—7
Metrarabdotos, 276
Michelinia, 111
Michelinoceras, 537, 219—15
clarkesvillense, 537, 219—10, 11
multicameratum, 537, 219—1, 2
pelops, 537, 219—12
sociale, 537, 219—4–6
subulatum, 537, 219—3
Micrabacia, 117
americana, 117
cribraria, 117, 43—14, 15
hilgardi, 117, 43—7–10
rotatilis, 117, 43—11–13
Micranellium, patuxentium, 491, 200—28
Micraster, 226
americanus, 226, 90—6–9
deshayesi, 226
peinei, 226
Microceras, 439
Microcoelodus, 241
typus, 241, 93—70
Microcyclus, 85
discus, 85, 23—15–18
thedfordensis, 85, 23—19–23
Microdiscus, dawsoni, 609
Microdoma, 471
conicum, 471, 192—9–11
Micromitra, 287
sculptilis, 287, 108—1–3
Micropedina, symmetrica, 226, 88—11–14

Micropora, 273
coriacea, 273, 103—26
Microptychis, 461
crenimarginatus, 461, 186—28, 29
wrighti, 461
Mictocrinus, 154
Miliolites, secalicus, 23
Millardia, 627
Millepora, 58, 18—1–3
compressa, 275
Milleratia, 665
cincinnatiensis, 665, 281—10–13
Mimella, 299, 301
melonica, 299, 112—44–47
vulgaris, 299
Mimospira, 439
Miogypsina, 47, 48
gunteri, 48, 14—3, 4
hawkinsi, 48, 14—1, 2
panamensis, 48, 14—5
Miogypsinopsis, 48
gunteri, 48, 14—3, 4
Miolepidocyclina, 48
panamensis, 48, 14—5
Miskoa, 228
Missouricrinus, 175
Mitcheldeania, 715
gregaria, 302—15
Mitoclema, 251
cinctosum, 251
mundulum, 251, 96—11
Mitra, 509
acteoglypha, 509, 210—9
dumosa, 508
fusoides, 509
millingtoni, 509
tessellata, 509
Mitrella, 500
carinata gausapata, 500, 205—24
communis, 500, 205—25
flaminea, 500
Mitrospira, 469
Mixochoanites, 366, 535
Mizzia, 715
velebitana, 302—1
yabei, 302—2
Modiella, 393
pygmaea, 393, 153—11
Modiodesma, 411
modiolare, 411, 164—6
Modiolodon, 411
oviformis, 411, 163—22, 23
patulus, 411, 163—25, 26
Modiolopsis, 409, 411, 417
cincinnatiensis, 411
concentrica, 409, 163—29, 30
mytiloides, 409, 163—27
oviformis, 411
plana, 411
valida, 409, 163—28
Modiolus, 413
Modiomorpha, 371, 409, 411
concentrica, 409, 164—2
mytiloides, 409, 164—1
Modocia, 627, 629
oweni, 629, 265—39–41
Mollia, antiqua, 273
Mollusca, 366
incertae sedis, 523
Molopophorus, 517
striatus, 517, 212—27
Monactinellida, 49, 51, 56
Monilopora, 113
Monobathra, 189
Monoceratina, 693
celsalobata, 693, 292—22–25
Monoceratina, dornickhillica, 693, 292—31, 32
pedata, 693, 292—33, 34
rossae, 693, 292—41
ventralis, 693, 292—26–30
Monocheilus, 629
anatinus, 629, 266—1–3
Monocraterion, 234
Monoculus, polyphemus, 707
telemus, 517
Monocyclica, inadunata, 143
Monodilepas, 480
Monograptus, 1, 64, 75, 77
bohemicus, 77, 22—23
clintonensis, 75, 22—20, 21
nilssoni, 75, 22—24
Monomerella, 287
prisca, 287, 107—34–36
Monopleura, 421
imbricata, 421
marcida, 421, 168—9, 10
pinguiscula, 421, 168—8
texana, 421, 168—6, 7
Monopteria, 391
gibbosa, 393, 152—27
longispina, 393, 152—26
Monotis, 393
salinaria, 393
subcircularis, 393, 152—29
Monotrypa, 259
magna, 261, 99—3, 4
Montastrea, 119
costata, 119, 44—4
imperatoris, 119, 44—7
roemeriana, 119, 44—5, 6
travisensis, 119, 44—3
Monticularia, conferta, 63
Monticulipora, 255
implicata, 259
mammulata, 255, 257
Monticuliporella, 255
arborea, 255, 97—1, 2
Montlivaltia, 117
caryophyllata, 117
norica, 117, 43—18, 19
Moorefieldella, 315
eurekensis, 315, 120—35–37
Mooreoceras, 553
normale, 553, 226—14, 15
Moorites, 673
convexus, 673, 283—13, 14
hewetti, 673
minutus, 673, 283—12
Mopalia, 527
muscosa, 527, 216—35–37
Morea, 505
cancellaria, 505, 208—6, 7
Morphotropis, 475
Morrowcrinus, 171
Mortoniceras, 593
shoshonense, 593, 247—9–16
texanum, 593, 247—6–8
Mourlonia, 457
filitexta, 457, 184—36
itys, 457, 185—3
lucina, 457, 184—35
mississippiensis, 457, 185—1, 2
Mucrospirifer, 321, 323
argentarius, 321, 122—7, 8
consobrinus, 321, 122—9, 10
mucronatus, 321, 122—4–6
thedfordensis, 321, 122—15, 16
Muensteroceras, 571
parallelum, 571, 233—19, 20
Multicostella, 297
platys, 297
saffordi, 297, 111—27–31

Multicrescis, parvicella, 251
Multioistodus, 237
subdentatus, 237, 93—10, 19
Multivasculatus, 55
ovatus, 55, 16—37, 38
Munsteroceras, 571
Murchisonia, 459
bicincta, 449
compacta, 459
davidsoni, 459
desiderata, 459, 186—1, 2
gouldii, 459, 186—6–8
gracilis, 457
lasallensis, 459
maia, 459, 186—4, 5
milleri, 449
nieszkowskii, 459
putilla, 459
soluta, 449
tropidophora, 449
vincta, 459, 186—3
Murex, 503, 505
antiquus, 505
canaliculatus, 503
caricum, 501
ficus, 500
filosus, 507
gibbosus, 514
gibbulus, 507
mississippiensis, 505, 207—13
pecten, 505
reticulatus, 495
scriptus, 500
tribulus, 505
tubifer, 503
tulipa, 507
Muricites, turbinatus, 459
Mya, 431
gibbosa, 413
producta, 431, 173—4–6
truncata, 431
Myacea, 431
Myalina, 393
arkansana, 393, 153—6
aviculoides, 393, 153—7
copei, 393, 153—10
goldfussiana, 393
illinoisensis, 393, 153—6
keokuk, 393, 153—4
perattenuata, 393, 153—5
recurvirostris, 393, 153—9
subquadrata, 393, 153—8
wyomingensis, 393, 153—9
Myelodactylus 143
convolutus, 143, 54—26
keyserensis, 145, 54—27
nodosarius, 145, 54—25
Myophoria, 401
alta, 401, 159—5
vulgaris, 401
Myriopoda, 599, 701
Myrtillocrinus, 153
americanus, 153, 57—16
elongatus, 153
Mysticocrinus, 153
wilsoni, 153, 54—23
Mytilacea, 409
Mytilarca, 387
chemungensis, 387, 149—32, 33
fibristriata, 387, 149—31
Mytilus, 413
conradinus, 413, 164—19
edulis, 413
hirundo, 391
modiolus, 413
polymorphus, 413
Mytilus, rugosus, 431
Myzostomida, 228

N

Naedyceras, 561
eugenium, 561, 230—9
Naiadacea, 399
Naiadites, 399
carbonarius, 399, 155—18
elongata, 399
Nanno, 535
aulema, 535, 218—3, 4
Nanonavis, brewerianus, 379, 146—47
Nanorthis, 295
hamburgensis, 295, 110—39–42
putilla, 295
Nassa, cancellata, 501
Natica, 485
ampullaria, 483
clausa, 485, 199—1
crenata, 483
eminula, 485
helicoides, 481
infundibulum, 483
marylandica, 485, 199—2
mediavia, 485, 199—3
semilunata, 485, 199—4
spirata, 481
tuomeyana, 483
williamsi, 485, 199—5, 6
Naticidae, 435
Naticodon, 475
Naticonema, 475
lineata, 475, 194—6, 7
similare, 475
Naticopsis, 475
carleyana, 475, 194—15, 16
nodosa, 475
phillipsii, 475
scintilla, 475, 194—22, 23
subovata, 475, 194—20, 21
transversa, 475, 194—24
ventricosa, 475, 194—17–19
Nautiloidea, 366, 528, 529
Nautilus, 528, 549
aturi, 549
auriculus, 39
bucinum, 555
burtini, 549
comatus, 31
coronatus, 547
dekayi, 549
ferratus, 545
incrassatus, 33
inelegans, 555
inflatus, 29
jason, 543
kelloggi, 541
legumen, 32
macellus, 33
montgomeryensis, 545
natator, 543
orbiculatus, 549
parkinsoni, 549
peramplus, 547
ponderosus, 547
pseudo-elegans, 549
quadrangulus, 547
radicula, 31
repandus, 39
sangamonensis, 547
spectabilis, 547
sphaericus, 571
springeri, 549
Naviculopsis, 11
biapiculata, 11, 14—9, 10

Nebraskacrinus, 159
tourtelota, 159, 60—13
Nebrodites, 587
rota, 587, 242— 18–20
Neidium, iridis, 301—38
tumescens, 301—37
Neithea, 405
roemeri, 405, 161—6
texanus, 405, 161—2
Nemagrapsus, elegans, 71
Nemagraptus, 71
gracilis, 71, 21—26
Nemathelminthes, 228
Nematopora, 265
ovalis, 265, 101—12
Nemodon, 379
brevifrons, 379, 146—50, 51
conradi, 379
eufaulensis, 379, 146—49
sulcatinus, 379, 146—48
Neobulimina, 35
canadensis, 35, 8—16
Neocoleodus, 237
spicatus, 237, 93—20
Neocomites, 587
kellumi, 587, 243—4, 5
Neodimorphoceras, 575
texanum, 575, 236—5, 6
Neogastropoda, 366, 477
Neoglyphioceras, 571
bellilineatum, 571
subcirculare, 571, 234—6–8
Neolenus, 613
Neomeris, 715
Neoshumardites, 575
sp., 575
triceps, 575
Neospirifer, 325
cameratus, 325, 125—5, 6
condor, 327, 125—1, 2
dunbari, 325, 125—7, 8
texanus, 325, 125—3, 4
Neotremata, 283, 284, 287
Neozaphrentis, 91
racinensis, 91, 27—21, 22
tenella, 91, 27—18–20
wannensis, 91, 27—23–26
Neozeacrinus, 167, 52—13
praecursor, 167, 63—21
uddeni, 167, 62—15; 63—22
Nephriticeras, 555
bucinum, 555, 228—6, 7
Nephrolepidina, 45
fragilis, 45, 13—11, 12
Neptunea, 505
lirata, 505, 207—6
tabulata, 505, 207—7
Nereidavus, 229
invisibilis, 229, 91—47
ontarioensis, 229, 91—48
planus, 229, 91—49
solitarius, 229, 91—50
varians, 229, 91—46
Nereus, arctinurus, 637, 271—9
Nerinea, 435, 495
austinensis, 495, 203—8
cultrispira, 495, 203—7
goodelli, 495, 203—1, 2
tuberculosa, 495
Nerinella, 495
dupini, 495
stantoni, 495, 203—9–11
subula, 495, 203—12
Nerita, 479
islandica, 481
perversa, 479
Nerita, vitellus, 485
Neritina, 479
Neritomopsis, 475
Nervostrophia, 341
nervosa, 341, 131—22, 23
rockfordensis, 341, 131—24, 25
Neurodontiformes, 237
Nevadocoelia, 51
wistae, 51, 15—16, 17
Neverita, 481
duplicata, 483, 198—6
josephina, 481
olla, 481
reclusiana, 483, 198—5
Newsomella, 414
ulrichi, 414, 164—34, 35
Nicholsonella, 259
ponderosa, 259
pulchra, 259, 98—30
vaupeli, 259, 98—31, 32
Nidulites, 57
favus, 57
pyriformis, 57, 17—21
Nileus, 649
armadillo, 649
scrutator, 649, 267—34, 35
Nipterocrinus, 181, 66—5
wachsmuthi, 181, 69—2
Nisusia, 284, 293
festinata, 293, 110—5–7
montanensis, 293 110—8–11
spencei, 293
Nitidiscala, tinctum, 481, 197—24, 25
Nodosarella, 37
coalingensis, 37, 8—23
Nodosaria, 31, 32
affinis, 31, 6—11–13
obliqua, 31
Nomismoceras, discus, 571
Nonion, 33
advenum, 33, 7—7
Nonionella, 33
miocenica, 33, 7—8
Nonionina, canariensis, 15
sphaeroides, 41
Norwoodella, 629
halli, 629, 266—5, 6
saffordi, 629, 266—4
Norwoodia, 629
gracilis, 629, 266—16
saffordi, 629
Nothognathella, 243
typicalis, 243, 94—26
Nucleocrinus, 135
bondi, 135, 51—10–12
elegans, 135
obovatus, 135, 51—9
verneuili, 135, 51—3–6
Nucleospira, 283, 331
concinna, 331, 127—5–7
pisiformis, 331, 127—10, 11
ventricosa, 331, 127—8, 9
Nucula, 373, 375, 377
arctica, 377
bellistriata, 375, 145—23
beyrichi, 375, 145—25
cancellata, 375, 145—34
corbuliformis, 375, 145—24
croneisi, 375, 145—30, 31
divaricata, 375
girtyi, 375, 145—26, 27
lirata, 375, 145—21
montpelierensis, 375, 145—32, 33
opima, 375, 145—22
ovula, 375, 145—36
percrassa, 375, 145—37, 38

Nucula, planimarginata, 375, 145—35
randalli, 375, 145—22
slackiana, 375, 145—28, 29
ventricosa, 375, 145—26, 27
Nuculacea, 373
Nuculana, 377
acuta, 377, 146—26, 27
astoriana, 377, 146—33
bellistriata, 377, 146—30, 31
diversa, 377, 146—34
gabbi, 377, 146—32
parva, 377, 146—28
rostellata, 377, 146—29
washingtonensis, 377, 146—35
Nuculites, 377
constricta, 377
planulata, 377
oblongatus, 377, 146—13, 14
subemarginata, 371
triqueter, 377, 146—15, 16
Nuculoidea, 375
lirata, 375, 145—21
opima, 375, 145—22
Nuculopsis, 375
croneisi, 375, 145—30, 31
girtyi, 375, 145—26, 27
Nummulites, globulina, 47
mantelli, 45
Nuttallina, 527
californica, 527, 216—1-5
Nyassa, 399
arguta, 399, 155—13, 14
Nyctocrinidae, 189
Nyctocrinus, 189
magnitubus, 189, 77—23

O

Obolacea, 283, 285
Obolella, 287
chromatica, 287, 108—8-11
cingulata, 293
crassa, 287
desiderata, 285
Obolus, conradi, 285
labradoricus, 287
Ochetoceras, 583
mexicanum, 583, 240—17, 18
Ocnerorthis, 293
cooperi, 293, 110—22-25
Octocoralla, 103
Octonaria, 682
alticostata, 682, 286—30, 31
altoonensis, 682, 286—26, 27
deltisulcata, 682, 286—28, 29
octoformis, 682
stigmata, 682, 286—23-25
Oculina, 121
Odontocephalus, 649
aegeria, 649, 273—4-6
Odontoceras, koeneni, 587
Odontochile, 649
micrurus, 651, 273—3, 11
micrurus clarkei, 651, 273—12
Odontopleura, 641, 651
callicera, 651, 271—16
ovata, 651
parvula, 651, 271—2
tuberculata, 651, 271—11-13
Odostomia, 481
conoidea, 481, 197—21
impressa, 481, 197—22, 23
Oedorhachis, 601
typicalis, 601, 251—18
Oenone, 229
Oenonites, 229
acinaces, 231, 91—55
Oenonites, amplus, 231, 91—73
coalescens, 231, 91—54
cuneatus, 229, 91—56
curvidens, 229, 91—51
exactus, 231, 91—59
excelsus, 231, 91—72
fornicatus, 231, 91—57, 58
orthodontus, 231, 91—60, 61
rostratus, 229, 91—71
serratus, 231, 91—52
tacitus, 231, 91—53
Ogygia, klotzi, 613
problematica, 611
Ogygopsis, 613
klotzi, 613, 258—16
Ohiocrinus, 151
Oistodus, 239
acuminatus, 240, 93—24, 25
inaequalis, 240, 93—44
lanceolatus, 239, 240, 93—23
Oklahomacrinus, 167
loeblichi, 167, 56—25
supinus, 167, 56—24; 62—19
Oldhamia, 719
occidens, 719, 303—17-19
radiata, 719
Olenellus, 613, 615, 619
bröggeri, 609
gilberti, 613, 253—2, 3
iddingsi, 615
thompsoni, 613, 253—4
vermontanus, 613, 253—1
walcottanus, 619
Oleneothyris, 283, 365
harlani, 365, 143—44-49
Olenoides, 613
curticei, 613, 256—4
desiderata, 607
inflatus, 613, 256—15, 16
nevadensis, 613, 256—18
serratus, 613, 256—1
spinosus, 619
stissingensis, 617
superbus, 613, 256—20
Olenopsis, americanus, 613
Olenus, 635
pecten, 623
thompsoni, 613
Oligochaeta, 228
Oligoporus, 217
danae, 217, 82—17-19
missouriensis, 217
Oligoptycha, 515
americana, 515, 212—7, 8
concinna, 515
obliqua, 515, 212—9
Oliva, 511
corticata, 511
dama, 511
litterata, 511, 210—11
purpurata, 511
sayana, 511, 210—11
Olivella, 511
alabamensis, 511, 210—13
mutica, 511, 210—12
Olivula, 511
marysvillensis, 511, 210—14, 15
staminea, 511, 210—16
staminea punctulifera, 511
Omphalia, 491
Omphalotrochus, 467
conoideus, 467, 191—5-7
ferrieri, 467, 191—5-7
obtusispira, 467, 191—12-15
whitneyi, 467, 191—21
Oncoceras, 557

Oncoceras, constrictum, 557, 228—10, 11
magnum, 561
mumiaforme, 557
orcas, 559
pandion, 557
Onniella, meeki, 353, 138—11–14
Ontaria, 373
suborbicularis, 373, 145—12–14
Onychaster, 213
flexilis, 213, 81—9–15
Onychocella, levinseni, 273
Onychocrinus, 179, 67—13
asteriaeformis, 179, 69—10
exsculptus, 179, 69—19
pulaskiensis, 179, 69—3
ulrichi, 179, 69—15
Onychophora, 599
Operculina, 33
incerta, 15
ocalana, 33, 7—13
Ophiceras, 569
subquadratum, 571, 233—21–23
tibeticum, 569
Ophileta, 447
compacta, 467
complanata, 447, 181—30–32
grandis, 449, 181—28, 29
hunterensis, 449, 181—33, 34
levata, 449, 181—26, 27
rotuliformis, 449, 181—25
Ophiletina, 467
sublaxa, 467, 189—18–20
Ophiura, 213
marylandica, 213, 81—16
texturata, 213
Ophiuroidea, 123, 213
Öpikina, 337
minnesotensis, 337, 129—11
septata, 337, 129—14–16
Opisthobranchia, 366, 515
Orbicella, 119
Orbicula, filosa, 291
grandis, 291
lamellosa, 291
squamiformis, 293
terminalis, 289
Orbiculoidea, 282, 291
forbesi, 291
media, 291
missouriensis, 291, 109—24
Orbitoides, 43
media, 43
palmeri, 45, 12—7, 8
Orbitolina, 31
gigantea, 31
texana, 31, 6—2
vesicularis, 43
Orbitolites, socialis, 45
Orbitremites, 133, 137
norwoodi, 137, 51—37–41
Orbitulites, pratti, 47
Orestes, 455
nodosus, 455
Ormoceras, 555, 557
allumettense, 555, 227—13, 14
bayfieldi, 555
Ornopsis, 507
glenni, 507, 208—18
Orophocrinus, 134
conicus, 134, 50—6, 7
stelliformis, 134, 50—8, 9
Orospira, 467
bigranosa, 467, 189—31
Orria, 613
elegans, 613, 259—1, 2
Orthacea, 283, 284, 293
Orthambonites, 295
eucharis, 295, 110—47–50
michaelis, 295
parva, 355
transversa, 295
Orthaulax, 497
gabbi, 499, 204—18–20
inornatus, 497
pugnax, 499, 204—16, 17
pugnax hernandoensis, 499, 204—16, 17
Orthis, canalis, 351
carinata, 353
carleyi, 298
clytie, 355
dubia, 355
dutertrei, 341
eifelensis, 353
electra, 295
elegantula, 353
gibbosa, 299
hamburgensis, 295
insculpta, 297
insignis, 301
interplicata, 297
kankakensis, 298
linneyi, 309
pectinella, 297
pepina, 293
planoconvexa, 355
plicatella, 299
quadricostata, 311
remnicha, 295
saffordi, 297
sinuata, 299
strophomenoides, 301
subaequata, 357
subcarinata, 353
subquadrata, 298
testudinaria, 353
tricenaria, 295
uberis, 353
umbonata, 329
verneuili, 297
Orthisina, festinata, 293
Orthoceras, 1, 537
brainerdi, 535
cornu-oryx, 532
crotalum, 541
doricum, 539
formosum, 539
hastatum, 557
knoxense, 553
lamarcki, 533
marcellense, 539, 220—6, 7
medullare, 541
michelini, 537
python, 555
richteri, 555
rivale, 537
typus, 539
wauwatosense, 539
Orthoceratites, alveolaris, 595
regularis, 537
Orthochoanites, 366
Orthodesma, 369
canaliculatum, 369, 144—12, 13
rectum, 369, 144—11
subnasutum, 369, 144—14, 15
Orthograptus, calcaratus, 73, 21—1
nexus, 73, 22—3
peosta, 73, 22—6, 7
Orthonema, 475
conicum, 475, 195—2
marvinwelleri, 477, 195—3, 4
salteri, 475, 195—1
schucherti, 477, 195—5

Orthonota, 369
undulata, 369, 144—9, 10
Orthonotacythere, 693
cristata, 693, 292—35
hannai, 693, 292—42–45
Orthonychia, 473
conicum, 473, 193—17
parvum, 473, 193—11, 12
quincyense, 473, 193—18
subrectum, 473, 193—19
tribulosum, 473, 193—8
Orthophragmina, floridana, 47, 13—19
Orthopsis, occidentalis, 226, 88—21, 23
Orthorhynchula, 309
linneyi, 309, 117—41–47
stevensoni, 309
Orthostrophia, 301
sp., 301, 113—13
strophomenoides, 301, 113—38–40
Orthosurcula, 514
francescae, 514, 211—9
persa, 514, 211—28
Orthotetes, 343
kaskaskiensis, 345, 133—5–8
keokuk, 343, 133—1–4
radiata, 343
Orthotheca, 525
cylindrica, 525
emmonsi, 525, 214—38–40
intermedius, 525
Orthovertella, 29
protea, 29, 5—11, 12
Ortonella, 715
Ortonia, 233
Oryctocara, 613
geikiei, 613, 259—8
Oryctocephalites, 613
typicalis, 613, 275—14, 15
Oryctocephalus, 613, 615
primus, 615
reynoldsi, 615, 257—23
Orygmaspis, 629
eryon, 629, 266—33, 34
Orygoceras, 533
cornu-oryx, 533, 217—14–16
Osceolia, 629
osceola, 629, 262—9, 10
Ostracites, angeiodes, 421
Ostracoda, 599, 660
Ostrea, 395, 397
carinata, 395, 397, 153—21
congesta, 395, 154—1, 2
cretacea, 395, 154—6, 7
cristagalli, 395
edulis, 395
elegantula, 395, 154—8, 9
falcata, 395, 154—10, 11
glabra, 395, 154—24, 25
haydeni, 395, 153—24, 25
hybrida, 405
larva, 395, 154—10, 11
lima, 407
lugubris, 395, 154—4, 5
mesenterica, 395, 154—16
operculons, 403
panda, 395, 154—3
pleuronectes, 405
plumosa, 395, 154—17, 18
quadriplicata, 395, 153—22, 23
sellaeformis, 395, 154—23
soleniscus, 395, 153—19
strigilecula, 395, 153—17, 18
subovata, 395, 153—20
subspatulata, 395, 154—14, 15
tecticosta, 395, 154—12, 13
titan, 397, 154—21, 22
Ostrea, trigonalis, 397, 154—19, 20
vesicularis, 397
vespertina, 397, 155—3
vomer, 397, 155—1, 2
Otospira, 475
Ottawacrinidae, 158
Ottawacrinus, 158, 52—5
billingsi, 158, 53—23
typus, 158, 53—24
Oulodus, 244
mediocris, 244, 94—7, 8
Ovoceras, 559
oviforme, 561, 230—7, 8
Ovulites, 715
Owenella, 441
antiquatus, 441, 176—7, 8
Owenoceras, 571
bellilineatum, 571, 234—11, 12
Oxoplecia, 282, 307, 105—8
calhouni, 307
gouldi, 307, 117—7–11
holstonensis, 307, 117—4
simulatrix, 307
Oxydiscus, 443
Oxyteuthis, 597
tehamaensis, 597, 250—11, 12
Oxytoma, 391
nebrascana, 391, 152—5
salinensis, 391, 152—8
submcconnelli, 391, 152—7
Oxytropidoceras, 589
belknapi, 589, 244—3
Ozarkina, 465
typica, 465, 188—43
Ozarkispira, 447
Ozarkodina, 244
regularis, 244, 94—17
typica, 244

P

Pachyaspis, 615
typicalis, 615, 255—7, 8
Pachydictya, 269
acuta, 270, 102—3, 4
crassa, 270, 102—5
fimbriata, 270, 102—1, 2
robusta, 269
Pachylocrinidae, 159
Pachylocrinus, 161
aequalis, 161, 60—10
globosus, 161, 60—17
lacunosus, 161, 64—21
mcguirei, 161
Pachyphyllum, 97
bouchardi, 97
woodmani, 97, 32—1, 2
Pachypora, 109
Pachyteuthis, 595
densus, 595, 250—6–8
Paedeumias, 615
transitans, 615, 254—18
Pagecrinus, 158
gracilis, 158, 57—4
Pagetia, 615
bootes, 615, 252—7–9
clytia, 615, 252—13–15
Pagodispira, 449
Paladin, 651
morrowensis, 651, 275—7, 8
Palaeacmaea, 437
irvingi, 437, 175—12, 13
quebecensis, 439, 175—11
typica, 437, 175—4
Palaeanatina, 371
quadrata, 371
typa, 371, 144—29

Palaeaster, 211
eucharis, 211
granulosus, 211
niagarensis, 211, 80—1–4
shafferi, 211
Palaeocapulus, 473
Palaeocaris, 697
typus, 697, 294—7, 8
Palaeochara, 713
acadica, 713
Palaeocidaris, 217
Palaeocoma, spinosa, 213
Palaeocreusia, 695
Palaeocrinidae, 153
Palaeocrinus, 153, 52—22
striatus, 151, 53—19
Palaeocystites, 127
tenuiradiatus, 127, 47—16–19
Palaeomanon, 53
cratera, 53, 15—18
Palaeoneilo, 377
constricta, 377, 146—20, 21
emarginata, 377, 146—24
fecunda, 377, 146—23
muta, 377, 146—22
sulcatina, 377, 146—25
Palaeopalaemon, 697
newberryi, 697, 294—12–16
Palaeopinna, 387
fiabella, 387, 150—12
Palaeoschisma, 455
Palaeosmilia, 97
murchisoni, 97
schucherti, 97, 31—12–14
Palaeostrophia, 301
elax, 301, 114—7–12
perilla, 301
Palaeostylus, 461
cylindratus, 461, 187—11
pupoides, 461
Palaeotremata, 283, 284, 293
Palaeoturbina, 471
Palasterina, rugosa, 211
Palastraea, 117, 119
decussata, 119, 43—20
Paleoalveolites, 105
paquettensis, 105, 36—1, 2
Paleochiridota, 227
plummerae, 227, 90—10
Paleoconcha, 366, 369
Paleocyclus, 83
fletcheri, 85
Paleofavosites, 107
prolificus, 107, 37—17
Paleolimulus, 707
avitus, 707, 300—1, 2
Paleschara, 271
incrustans, 271, 103—21
Palinurus, trigonus, 699
Palliseria, 469
longwelli, 469, 191—18, 19
robusta, 469, 191—20
Pallium, 403
estrellanum, 403
striatum, 403
swifti nutteri, 407, 161—19
Palmatodella, 244
delicatula, 244, 94—18
Palmatolepis, 245
glabra, 245, 94—40
perlobata, 245
rugosa, 245, 94—39
subperlobata, 245, 94—41
Palmula, 32
rugosa, 32, 6—14
sagittaria, 32

Paltodus, 240
arcuatus, 240, 93—26
elegans, 240, 93—34, 35
subaequalis, 240
Paludina, 485
magnifica, 487
Paludotrochus, trochiformis, 485, 199—12, 13
Panenka, 373
bohemica, 373
dichotoma, 373, 145—9
Panope, 431
aldrovandi, 431
decisa, 433, 172—21, 22
generosa, 433, 172—20
Parabolbina, 669
granosa, 671, 282—13
Parabolina, 629
spinulosa, 629, 263—12–14
Paracardium, 373
delicatum, 373
doris, 373, 145—15, 16
Paraceltites, 569
hoeferi, 569
ornatus, 569, 233—1, 2
Parachaetetes, 715
Paracyclas, 423
elliptica, 423, 168—15
lirata, 423, 168—14
ohioensis, 423, 168—13
Paracypris, 687
perapiculata, 687, 288—52
polita, 687
weatherfordensis, 687, 288—53, 54
Paradelocrinus, 173
aequabilis, 173, 62—3; 65—20
brachiatus, 173, 62—34; 65—25
dubius, 173, 62—31; 65—21
obovatus, 173, 65—22
planus, 173, 65—24
protensus, 173, 65—23
Paradichocrinus, 199
polydactylus, 199, 78—1, 6
Paradoceras, discoideum, 567, 231—14, 15
Paradoxides, 609, 615
abenacus, 615, 254—8
boltoni, 637
davidis, 615, 254—12, 13; 300—13, 14
eteminicus, 615, 254—1, 2
harlani, 615, 254—3–7
hicksi, 615, 254—9, 10
lamellatus, 615, 254—14, 15; 276—19
loveni, 609
matthewi, 615, 254—11
nevadensis, 613
tessini, 615
Paraechmina, 665
abnormis, 665
postica, 665
spinosa, 665, 280—49, 50
Parafusulina, 27
diabloensis, 25, 4—16, 17
lineata, 27, 4—3–6
rothi, 27, 4—10–12
sellardsi, 27, 4—7–9
wordensis, 25
Paragassizocrinus, 177
tarri, 177, 56—31
Paragastrioceras, 575
Paragazacrinus, 185
rotundus, 185, 72—25
Paralegoceras, 573
iowense, 573, 235—24, 25
sundiacum evoluta, 573
Paralichas, 654
Parallelodon, 379
brewerianus, 379, 146—47

Parallelodon, chemungensis, 379, 146—46
hamiltoniae, 379, 146—44
obsoletus, 379, 146—43
tenuistriatus, 379, 146—45
Paranomia, 409
scabra, 409, 163—20, 21
Paraparchites, 664
humerosus, 664, 280—27–30
inornatus, 664, 280—26
nicklesi, 664, 280—22, 23
wapanuckensis, 664, 280—24, 25
Parapelagiella, 439
Pararca, 373
erecta, 373, 145—19, 20
venusta, 373
Paraschwagerina, 25
gigantea, 25, 4—21, 22
kansasensis, 25, 4—23, 24
Parasmilia, 121
austinensis, 122, 45—30, 31
bullardi, 122, 45—32
Paraspirifer, 323
acuminatus, 323, 123—3–5
bownockeri, 323
Parastrophina, 303
hemiplicata, 303, 114—44–47
Paraturia, 549
Parazyga, 361
hirsuta, 361, 141—32–34
Parenteletes, 357
cooperi, 357, 140—21–23
Parichthyocrinus, 177, 67—9
meeki, 179, 69—12
nobilis, 177, 69—8
Parisocrinus, 154
siluricus, 154, 55—13
subramosus, 154, 57—20
Parmophorella, 437
Parmorthis, 353
waldronensis, 353, 138—31–33
Paromphalus, 465
Partretocycloecia, 251
dumosa, 251, 95—18, 19
Parulocrinus, 175
blairi, 175, 64—37
compactus, 175, 64—36
pustulosus, 175, 64—31
Paryphorhynchus, 311
elongatum, 311
striaticostatum, 311, 119—1–3
transversum, 311
Pasceolus, 719
Patella, apertura, 480
auricula, 487
auriculata, 487
chinensis, 487
fornicata, 489
graeca, 480
levetti, 469
unguis, 285
Patellina, 37
advena, 37, 9—8
corrugata, 37
Patelliocrinidae, 200
Patelliocrinus, 200
ornatus, 200, 73—16
pachydactylus, 200
rugosus, 200, 73—22
Paterina, 281, 287, 105—7
swantonensis, 287, 108—4–7
Paterinacea, 283, 287
Patinopecten, 405
healeyi, 407, 163—2
Paulocrinus, 183
biturbinatus, 183, 185, 72—20
Paurorhyncha, 313
Paurorhyncha, endlichi, 313, 119—20–22
sp., 313, 119—23–26
Paurorthis, 355
catawbensis, 355, 138—46–48
Peachella, 615
iddingsi, 615, 254—17
Pecten, 368, 403
adscensionis, 403
andersoni, 407, 162—8–10
aviculatus, 405, 160—14
bellistriatus, 405, 160—16
carboniferus, 403
caurinus, 405
choctavensis, 407, 161—17, 18
circularis, 405, 407, 157—5, 6
complexicosta, 405, 161—5
conradi, 405, 161—9, 10
crenulatus, 403
demissus, 405
estrellanus, 407, 162—3, 4
estrellanus terminus, 407, 161—20
fucanus, 407, 161—21, 22
greggi, 407
halli, 407, 161—15, 16
hallii, 405
healyi, 407, 163—2
islandicus, 403
jeffersonius, 407, 162—11
jeffersonius septenarius, 407, 162—7
johnsoni, 407, 161—14
lens, 405
madisonius, 407, 162—6
marylandicus, 407, 162—5
mortoni, 407, 163—1
nebrascensis, 405, 161—7, 8
neglectus, 403
operculiformis, 405, 161—1
peckhanis, 407, 162—1, 2
pedroanus, 407, 162—1, 2
perplanus, 407
pertenuistriatus, 405
platesia, 405, 161—4
prosseri, 405, 160—14
rigidus, 407, 161—15, 16
roemeri, 405, 161—6
semiplicatus, 405, 161—3
simplicius, 405, 161—11, 12
swifti nutteri, 407, 161—19
texanus, 405, 161—2
venustus, 405, 161—13
wahtubbeanus, 407
Pectinacea, 401
Pectinucula, 375
cancellata, 373, 145—34
Pectunculus, 383
Pedicellariae, 226, 89—24–45
Pelagiella, 439
atlantoides, 439, 175—17, 18
hoyti, 439, 175—19
Pelecocrinidae, 157
Pelecocrinus, 157
aqualis, 157, 55—19
insignis, 157, 58—10
Pelecypoda, 366, 367
Pellecrinus, 154
Pellucistoma, 689
Pelmatozoa, 123
Peltura, 629
scarabaeoides, 629, 262—16, 17; 276—24
Penniretepora, 265
carinata, 265, 100—26
conferta, 265, 100—27
Pentacrinidae, 205
Pentacrinus, 207
asteriscus, 207, 79—6

Pentacrinus, briareus, 207
californicus, 207, 79—10
knighti, 207, 79—3
subangularis alaska, 207, 79—8
Pentagonia, 333
bisulcata, 333, 127—32-36
unisulcata, 333, 127—37
Pentameracea, 283, 284, 303
Pentamerella, 305
arata, 305, 115—19-22
obsolescens, 305, 115—14, 15
pavilionensis, 305, 115—16-18
Pentameroides, 305
subrectus, 305, 115—23, 24
Pentamerus, 282, 305, 363
barrandei, 307
cylindricus, 305, 116—7
elongatus, 363
knappi, 305
laevis, 305, 116—1-4, 8, 9
oblongus, 305
occidentalis, 303
sieberi, 305
subrectus, 305
verneuili, 303
Pentaramicrinus, 171, 209
gracilis, 171, 64—30
Pentremite, 134
Pentremites, 133, 134
angustus, 134, 50—16-18
conoideus, 134, 50—11-13
derbiensis, 137
elongatus, 134, 50—10
godoni, 134, 50—14, 15
leda, 135
lineatus, 135
melo, 137
obesus, 134, 50—20, 21
pallettei, 134
pyriformis, 134, 50—19, 26
reinwardti, 135
rusticus, 134
sayi, 135
stelliformis, 134
woodmani, 135
Pentremitidea, 134, 135
americana, 135, 50—22
filosa, 134, 135, 50—23
goldringae, 135
Peracarida, 697
Perditocardenia, 355
dubia, 355, 139—30-34
Peregrinella, 315
whitneyi, 317, 120—64, 65
Periarchus, 221
lyelli, 221, 84—19-21
Periaulax, 480
mudgeana, 480, 197—6
Periechocrinites, 189, 191, 70—17
costatus, 189
tennesseensis, 189, 75—15
whitei, 189, 75—14
Periechocrinitidae, 189
Periglyptocrinus, 199
billingsi, 199, 73—25
Perimestocrinus, 161, 163
calyculus, 161, 64—2
formosus, 161, 64—3
impressus, 161, 62—8; 64—12
noduliferus, 163, 62—9; 64—5
pumilis, 161, 64—4
teneris, 161, 64—11
Perimneste, 713
corrugata, 713, 303—10-12
horrida, 713
Periporosella, 271
Periporosella, plebeia, 271, 103—19
rimulata, 271, 103—20
tantilla, 271
Perischoechinoida, 217
Perisphinctes, 587
elizabethaeformis, 587, 242—10-12
wartae antecedans, 587, 242—10-12
Perissocrinus, 147
Perissolax, 501
blakei, 501, 206—5
trivolvus, 501, 206—4
whitfieldi, 501, 206—1-3
Perissoptera, prolabiata, 499, 204—9
Peristerina, filicatus, 508, 208—13
Peritrochia, 575
erebus, 575, 236—22
ganti, 577, 236—20, 21
Pernopecten, 405
prosseri, 405, 160—14
Perprimitia, 665
funkhouseri, 667, 281—18, 19
robusta, 665, 281—20
Perrinites, 577
boesei, 577
hilli, 577
hilli hilli, 577, 237—1
Petalocrinidae, 153
Petalocrinus, 153
mirabilis, 153, 54—31
Petalotrypa, 258
compressa, 258, 97—26, 27
Petraia, minganensis, 51
stricta, 85
Petrocrania, 291
hamiltoniae, 291, 109—28-30
modesta, 291
scabiosa, 291, 109—31
Petrosites, 51
humilis, 51, 15—3
Peyrotia, 491
humerosa, 493, 201—18
tampae, 493, 201—19
Phacelocrinus, 171
dactyliformis, 171, 60—7
decabrachiatus, 171, 60—6
internodius, 171, 60—16
vanhornei, 171, 60—5
Phacelopora, 253
pertenuis, 253, 96—4
Phacoides, 423
acutilineatus, 423, 168—25
Phacops, 651, 653
bronni, 653
callicephalus, 639
cerathophthalma, 643
cristata, 651, 274—16, 17
handwerki, 645
latifrons, 651
logani, 651, 274—25, 26
rana, 651, 274—2-5
Phaethonides, cyclurus, 641
Phanerocephala, 228, 229
Phanerotrema, 453
labrosum, 453, 183—24-26
occidens, 453, 183—27
Phanocrinus, 171, 209
formosus, 171, 65—32
nitidus, 171, 64—35
Pharcoceras, dumbli, 549
Pharkidonotus, 445
percarinatus, 445, 179—24-26
tricarinatus, 445, 179—21-23
Philhedra, 291
baltica, 291
crenistriata, 293, 109—32, 33

Philhedra, laelia, 293, 109—34
Phillipsastreaea, verneuili, 97
Phillipsia, 639, 647, 651
nodocostata, 637, 275—23, 24
perannulata, 637
portlocki, 645
sampsoni, 651, 276—1-3
sangamonensis, 637
swallowi, 651, 276—4-6
Philoxene, 463
Phimocrinus, 151
Phlycticrioceras, 589
oregonense, 589, 244—1, 2; 249—11, 12
Pholadella, 414
newberryi, 414
radiata, 414, 165—8, 9
Pholadomya, 414
anteradiata, 414
candida, 414
papyracea, 414, 165—15, 16
undata, 415
Pholidops, 293
Pholidostrophia, 341
nacrea, 341, 132—1-3
Phragmoceras, 561
arcuatum, 561
nestor, 561, 230—10, 11
nestor canadense, 561
panderi, 561
parvum, 561, 230—6
Phragmodus, 241
primus, 241
undulatus, 241, 93—49, 50
Phragmolites, 443,
compressus, 443, 178—5
fimbriatus, 443, 178—6, 7
obliquus, 443, 178—3, 4
Phragmostoma, 445
Phricodothyris, 327
lucerna, 327
perplexa, 329, 126—9, 10
Phthonia, 369
sectifrons, 369, 144—3
Phyllacanthus, 219
mortoni, 219, 83—14, 15
Phylloceras, 581
oldhami, 577
onoense, 581, 239—19
Phyllocoenia, grandissima, 117
Phyllodictya, 269
frondosa, 269
varia, 269, 102—8-10
Phyllograptus, 64, 70
angustifolius, 70, 21—7
anna, 70, 21—8
ilicifolius, 70, 21—9
typus, 70, 21—11
Phymatifer, 465
Phymatopleura, 455
brazoensis, 455, 183—35, 36
nodosus, 455, 183—37
Phymosoma, 219
texanum, 219, 226, 83—17-19; 89—9
Physa, 519
copei, 519, 213—1, 2
globosa, 519
meigsii, 519, 213—4
pleromatis, 519, 213—3
Physella, 519
Physetocrinus, 193, 71—15
lobatus, 193, 77—8
ventricosus, 193, 77—7
Pileopsis, vetusta, 473
Pilina, 437
Piloceras, explanator, 535
newton-winchelli, 533
Pinacodus, 244
profundus, 244
Pinacognathus, 244
profunda, 244, 94—3
Pinna, 387
laqueata, 387, 150—7
prisca, 387
rudis, 387
Pinnatopora, 265
Pinnularia, major, 301—18
viridis, 301—19
Pionodema, 281, 357, 105—18
globosa, 299
minuscula, 357, 139—43-45
subaequata, 357, 139—46-49
Pirasocrinidae, 161
Pirasocrinus, 165
scotti, 165, 62—18; 63—23
Pisocrinidae, 147
Pisocrinus, 147, 54—19
baccula, 147 54—17
gemmiformis, 147, 54—14
pilula, 147
quinquelobus, 147, 54—15
sphericus, 147, 54—16
tennesseensis, 147, 54—18
Pitar, 427
horni, 427, 170—20
uvasana, 427, 170—21
Placenticeras, 595
guadalupe, 595, 249—9, 10
intercalare, 595, 249—6-8
meeki, 595
placenta, 595, 249—5
planum, 595, 249—3, 4
whitfieldi, 595, 249—1, 2
Placopecten, 405
marylandicus, 407, 162—5
Placopsilina, 31
cenomana, 31
ciscoensis, 31, 6—1
Placuna, scabra, 409
Plaesiomys, 298, 106—8
iphigenia, 298
meedsi, 298, 111—52, 53
strophomenoides, 297
subquadrata, 298, 111—54-58
ulrichi, 298
Plagioctenium, 405
andersoni, 407, 162—8-10
circularis, 407, 157—5, 6
Plagioglypta, 521
canna, 523, 214—31
Planorbis, 519
amplexus, 519, 213—14, 15
conanti, 519, 213—7, 8
leidyi, 519, 213—16, 17
planoconvexus, 519, 213—5, 6
spectabilis spectabilis, 519
spectabilis utahensis, 519, 213—11-13
veternus, 519, 213—20, 21
Plants, fossil, 711
Planularia, 31
advena, 31, 6—5
auris, 31
Planulina, 43
ariminensis, 43
harangensis, 43, 11—11
Plasmopora, 103
follis, 103, 35—6-8
Platyceras, 1, 435, 473, 475
conicum, 473, 193—17
cornutum, 473, 193—1, 2
dumosum, 473, 193—15, 16
haliotoides, 473, 193—9
niagarense, 473, 193—10

Platyceras, parvum, 473, 193—11, 12
quincyense, 473, 193—18
subrectum, 473, 193—19
tribulosum, 473, 193—8
turbinatum, 473, 193—13, 14
unguiforme, 473, 193—5–7
ventricosum, 473, 193—3, 4
Platycerina, 473
Platyclymenia, 565
americana, 565, 231—20
Platycolpus, 629
capax, 629, 260—24, 25
sinclairensis, 629, 260—22, 23
whitfieldi, 629, 260—20, 21
Platyconcha, 461
Platycrinites, 189, 203, 205, 71—8
allophylus, 203, 77—16
americanus, 203, 77—17
burlingtonensis, 203, 78—24
discoideus, 203, 77—26; 78—22
hemisphericus, 203, 205, 78—21
interscapularis, 197
laevis, 203
quinquenodus, 203, 78—19
saffordi, 205, 78—27
sculptus, 203, 78—25
spinifer elongatus, 203, 78—23
subspinulosus, 203, 78—20
symmetricus, 203, 78—26
verrucosus, 203, 78—18
Platycrinitidae, 203
Platycrinus, eriensis, 203
nodosus, 203
Platycyathus, scottianus, 121, 44—14–16
Platyhelminthes, 228
Platymetopus, 654
Platynotus, 637
Platyorthis, 355
planoconvexa, 355, 139—1–4
Platyostoma, 473, 475
cornutum, 473, 193—1, 2
turbinatum, 473, 193—13, 14
ventricosum, 473, 193—3, 4
Platyostomella, 475
Platyrachella, 283, 325
iowensis, 325, 123—22
mesastrialis, 325, 123—20, 21
oweni, 325, 123—23–26
Platystrophia, 282, 299, 301
acutilirata, 299, 113—21–24
crassa, 299, 113—32–35
cypha, 299, 113—36, 37
laticosta, 299, 113—25, 30, 31
ponderosa, 299, 113—41–44
reversata, 299, 113—26, 27
trentonensis, 299, 113—28, 29
Platytrochus, 121
merriami, 121, 45—24–26
stokesi, 121, 45—20, 21
Plaxocrinus, 163
crassidiscus, 163, 62—7; 63—7
discus, 163, 63—6
obesus, 163, 63—8
parilis, 163, 63—5
perundatus, 163, 63—9
politus, 163, 63—1
praevalens, 163, 62—5; 63—16
virginarius, 163, 63—2
Plectatrypa, 317
marginalis, 317
praemarginalis, 317, 120—66–68
Plectoceras, 543, 557
jason, 543, 222–6
undatum, 543, 222—10
undatum occidentale, 543
Plectoconcha, 365
Plectoconcha, aequiplicata, 365, 143—27–31
Plectodonta, 335
mariae, 335
transversalis, 335, 128—34–36
Plectofrondicularia, 35
californica, 35, 8—8, 9
concava, 35
Plectonotus, 441
Plectorthis, 299
fissicosta, 299, 112—41–43
plicatella, 299, 112—40
Plectostylus, 479
Plectotrophia, 301
bridgei, 301, 114—1–6
Pleospongia, 49, 56
Plesiaster, 226
americanus, 226, 90—6–9
Plestochilus, culbertsoni, 507, 208—10, 11
Plethobolbina, lativia, 665, 280—58, 59
Plethometopus, 631
convexus, 631, 260—6, 7
Plethomytilus, 387
oviformis, 387, 150—1
ponderosus, 387, 150—2, 3
Plethopeltis, 619, 621, 631, 633
buehleri, 631, 260—4, 5
saratogensis, 631, 260—1–3
Plethorhyncha, 311
speciosa, 311, 118—71–74
Pleuroclymenia, americana, 565, 231—20
Pleurocora, 119
coalescens, 119, 44—12
explanata, 119
texana, 119, 44—13
Pleurocystites, 129
filitextus, 129, 48—20, 21
squamosus, 129, 48—4, 16
Pleurodictyum, 111, 113
convexum, 111, 40—1–3
cylindricum, 111, 40—4
eugeneae, 111, 39—20, 21
lenticulare, 111, 39—25–27
problematicum, 111
styloporum, 111, 39—22–24
Pleurolimnaea, 519
tenuicostata, 519, 212—22, 23
Pleuromya, 413
inconstans, 413, 164—33
subcompressa, 413, 164—31, 32
Pleuronotus, 465
decewi, 465, 189—10, 11
Pleurophorus, 415
albequus, 415, 165—35, 36
oblongus, 415, 165—32
occidentalis, 415, 165—34
subcostatus, 415, 165—33
tropidophorus, 415, 165—31
Pleurostomella, 37
subnodosa, 37, 8—22
Pleurotoma, 514
acutirostra, 513
bottae, 513
childreni, 513
cristata, 513
gibbosa, 514
longiforma, 514
lunata, 513
Pleurotomaria, bilix, 471
callosa, 453
etna, 449
labrosa, 453
lartetti, 457
micula, 451
radula, 453
sphaerulata, 453

Pleurotomaria, subconica, 455
turbiniformis, 457
umbilicata, 451
Pleurotomariidae, 435
Pleurotrochus, 471
Plicatula, 407
densata, 407, 163—8, 9
hydrotheca, 407, 163—7
striatocostata, 345
Pliomera, 651
Pliomerops, 651
canadensis, 651, 272—23-25
Ploecyga, 463
angularis, 463, 187—31
corona, 463, 187—19
Plummericrinus, 161
meguirei, 161, 63—20
ogarai, 161, 62—35; 63—19
uddeni, 161, 63—18
Plummerinella, 29
complexa, 29, 5—14
Plumulites, 695
jamesi, 695
Podocratus, 699
Poleumita, 475
crenulata, 475, 194—13
scamnata, 475, 194—14
Poliella, 615
anteros, 615, 256—2, 3
Polinices, 483
albus, 483
halli, 483, 198—23, 24
mamillaris, 483
shumardianus, 483, 198—25
Polyactinia, 115
Polycaulodus, 239
inclinatus, 239, 93—9
sp., 239, 93—4
Polychaeta, 228, 229
Polydiexodina, 27
capitanensis, 27, 4—1, 2
Polygnathellus, 245
nothus, 245, 94—46
typicalis, 245, 94—52-54
Polygnathidae, 244
Polygnathodella, 246
fossata, 246, 94—70, 71
ouachitensis, 246
Polygnathoides, 245
siluricus, 245, 94—48, 49
Polygnathus, 244, 245
communis, 245, 94—29-31
concentrica, 245, 94—47
dubia, 245
gyratilineata, 245
lobata, 245, 94—36
symmetrica, 245, 94—35
Polygonal, tenuirugosus, 209, 79—22
Polygyrata, 447
Polylepidina, 45
gardnerae, 45, 13—17, 18
Polylophodonta, 245
concentrica, 245, 94—47
gyratilineata, 245
Polymorphina, 32
burdigalensis, 32
charlottensis, 32, 7—5
communis, 32
gibba, 32
Polymorphocodium, 715
Polyphemopsis, 477
Polyplacophora, 366, 526
Polypora, 264
cultellata, 264, 100—9, 10
dendroides, 264
elliptica, 264, 100—14
Polypora, incepta, 264, 100—12, 13
shumardi, 264, 100—9, 10
submarginata, 264, 100—11
Polystomella, arctica, 33
Polytaxis, 31
laheei, 31
multiloculata, 31, 5—18
Polytoechia, 298
alabamensis, 298
apicalis, 298, 112—19-21
montanensis, 301
Polytropina, 475
Polytropis, 475
Polytylites, 673
directus, 673, 283—10
geniculatus, 673, 283—4-7
Polyzoa, 247
Pomatotrema, 282, 298
muralis, 298, 112—15-18
Ponderodictya, 685
bispinulata, 687, 288—55-58
Pontocypris, 683
arcuata, 683, 288—1-3
perforata, 683, 288—4, 5
serrulata, 683
Popanoceras, 577
bowmani, 577, 236—24, 25
Porella, 275
jacksonica, 276, 104—11
Porifera, 49
Porites, expatiatus, 109
petalliformis, 103
Porocrinus, 153, 52—22
conicus, 153, 53—13
Porodiscus, concentricus, 48, 14—23
Porpites, 83, 85
globulatus, 83
michiganensis, 83, 23—6-8
rotuloides, 83, 23—4, 5
Portlockia, 451
Poteriocrinites, 155, 157, 52—18
crassus, 155
macropleurus, 155, 58—3
Poteriocrinitidae, 155
Poteriocrinus, bursaeformis, 159
coreyi, 169
coxanus, 157
dilatatus, 159
hemisphericus, 171
hoveyi, 169
jesupi, 158
magniventrus, 157
perplexus, 154
regularis, 159
scalaris, 169
wetherbyi, 171
Poulsenia, 615
cossus, 615, 259—4, 5
granosa, 615, 259—6, 7
Pourtalesia, wandeli, 89—30-32
Praenatica, 473
expansa, 473, 194—36
Prasopora, 257
grayae, 257
simulatrix, 257, 97—18, 19
Preshumardites, 573
Prestwichia, 707
Primitia, 665, 667
dentifera, 675
lativia, 665, 280—58, 59
sculptilis, 665
seriata, 665, 280—56, 57
Primitiella, 665
constricta, 665, 281—1-4
unicornis, 665, 281—5-7
Primitiopsis, striatus, 681

Prioniodidae, 240
Prioniodina, 244
subcurvata, 244, 94—24
Prioniodinidae, 243
Prioniodus, 241, 243
bidentata, 243, 94—20
corniger, 241, 93—54
elegans, 241, 93—53
Prionocyclus, 593
wyomingensis, 593, 247—3-5
Prionodesmacea, 366, 369
Prionothyris, 364
condoni, 364, 142—20, 21
perovalis, 364, 142—16-19
Prionotropis, 593
woolgari, 593, 247—1, 2
Prionotus, pristis, 73
Priscochiton, 526
canadensis, 526, 216—6-8
Priscoficus, 500
argutus, 500, 205—18, 19
caudatus, 500, 205—12
juvenis, 500, 205—13, 14
Prismatophyllum, 95
davidsoni, 95
Prismodictya, 55
prismatica, 55, 16—27
telum, 55, 16—15
Prismopora, 270
triquetra, 270, 102—21
Proagnostus, 601
bulbus, 601, 251—3, 4
Proarcestes, shastaensis, 581, 239—7, 8
Probeloceras, 565
lutheri, 565, 231—5
Proboscina, 250
admota, 250, 95—15
boryi, 250
clavatula, 250, 95—13
frondosa, 250, 95—14
Prodromites, 567
gorbyi, 567, 232—10, 11
Productacea, 283, 284, 345
Productella, 347
hirsutiformis, 349, 135—27, 28
lachrymosa, 347
spinulicosta, 347, 135—29, 30
truncata, 347, 135—21-23
walcotti, 349, 135—24-26
Productus, 1, 349
cora, 351
elegans, 349
humboldti, 351
juresanensis, 350
leonardensis, 351
magnus, 350
marginicinctus, 349
punctatus, 1
setigerus, 350
subaculeatus, 347
youngianus, 349
Proeccyliopterus, 439
Proetus, 643, 651
crassimarginatus, 651, 274—18, 19
haldemani, 653, 274—6
longicaudus, 637, 275—23, 24
missouriensis, 653, 276—9, 10
nevadae, 653, 276—8
rowi, 653, 274—10
Prolecanites, 567
greeni, 567, 231—18, 19
mojsisovics, 567
Proliostracus, 615
goodwini, 615, 255—10, 11
strenuelliformis, 615
Promopalaester, 211
Promopalaester, bellulus, 211, 81—2-5
speciosus, 211
spinulosus, 211
Promourlonia, 457
Pronorites, 567
arkansasensis, 567, 232—1, 2
Proparreysia, holmesianus, 399, 158—17, 18
Properrinites, 577
boesei, 577, 236—26-29
Propinacoceras, 567
beyrichi, 567
knighti, 569, 232—8, 9
Proplina, 437
acuta, 437, 174—4-6
barabuensis, 437, 174—9, 10
cornutaformis, 437, 174—11
unguiformis, 437, 174—7, 8
Propora, 103
Proporocyclina, 47
flintensis, 47, 12—9
perpusilla, 47, 12—16, 17
Prorhynchus, 371
angulatum, 371, 144—30
Prorichthofenia, 351
uddeni, 351, 138—43-45
Prosaukia, 631
misa, 631, 261—9-11
Prosigaretus, 473
Prosobranchia, 366, 439, 479
Prosoptychus, 443
Prosserella, 329
modestoides, 329, 126—11, 12
Protarabellites, 231
canadensis, 231, 91—67, 68
concavus, 231, 91—66
excelsus, 231, 91—69
giganteus, 231, 91—70
glenwoodensis, 231, 91—64
hamiltonensis, 231, 91—63
humilis, 231, 91—65
productus, 231, 91—62
Protaxocrinus, 177, 67—11
elegans, 177, 68—14
laevis, 177, 69—7
robustus, 177, 54—13
Proteonina, 13
difflugiformis, 13, 1—1
fusiformis, 13
Proterocameroceras, 535
brainerdi, 535, 218—11-14
Prothyris, 369
elegans, 369, 144—7
lanceolata, 369, 144—8
Protichnites, 719
logananus, 719, 303—38
septemnotatus, 719
Protistograptus, 69
Protobalanus, 695
hamiltonensis, 695, 293—13
Protobusycon, cretaceum, 501, 206—15, 16
Protocanites, 567
lyoni, 567, 231—21-23
Protocardia, 425
subquadrata, 425, 169—14, 15
texana, 425, 169—16
Protocaris, 655
marshi, 655, 277—2
pretiosa, 655, 277—3, 4
Protocaudina, 227
kansasensis, 227, 90—14-16
traquairii, 227, 90—11-13
Protochoanites, 366, 531
Protocycloceras, 533
lamarcki, 533, 217—10, 11
Protogastropoda, 366, 437

Protokionoceras, 541
medullare, 541, 221—1
Protolenus, 615
elegans, 617, 253—9
paradoxides, 615
Protoleptostrophia, 341
perplana, 341, 131—15–17
Protomegastrophia, 339
profunda, 339, 129—12, 13
Protoperlaria, 298—11
Protorhyncha, ridleyana, 307, 117—30–33
Protoscutella, 221
mississippiensis, 221, 85—10–12
Protospongia, 53
fenestrata, 53, 16—6
Protothalassoceras, inexpectans, 575
Prototreta, 281, 289
attenuata, 289
trapeza, 289, 108—29–33
Protowarthia, 441
Protozoa, 11
Protozyga, 317
nicolletti, 317, 120—52, 53
Protrachyceras, shastense, 579, 238—21–23
Protremata, 282, 283, 284
Prouddenites, 567
primus, 567, 232—12, 13
Prozacanthoides, 617
optatus, 617, 257—8, 9
virginicus, 617, 257—7
Psammechinus, 221
philanthropus, 221, 84—11–13
Pseudagnostus, 601
josepha, 601, 251—5, 6
Pseudamusium, 405
pedroanus, 407, 162—1, 2
Pseudaviculopecten, princeps, 403, 160—3
Pseudoceratites, 529
Pseudochaetetes, 715
Pseudocrinites, 127
bifasciatus, 127
clarki, 128, 47—33–35
gordoni, 128, 47—30–32
Pseudogastrioceras, 573
altudense, 575, 236—1, 2
Pseudoglandulina, 31
conica, 32, 6—8
Pseudohornera, 261
diffusa, 263, 99—17, 18
Pseudolepidina, 43
trimera, 43, 12—3, 4
Pseudolisania, 631
breviloba, 631, 266—11–15
Pseudometacoceras, 547
sculptile, 547, 224—7, 8
Pseudomonotis, 393
curta, 393, 152—25
equistriata, 393, 152—23
hawni, 393, 152—24
Pseudonotostraca, 655
Pseudoparalegoceras, 573
brazoense, 573, 235—5
Pseudophragmina, 47
cookei, 47, 12—12, 13
flintensis, 47, 12—9
perpusilla, 47, 12—16, 17
Pseudopolygnathus, 244
prima, 244, 94—11, 12
Pseudopolymorphina, 32
hanzawai, 32
rutila, 32, 7—3
Pseudorbitoides, 45
israelskii, 45, 12—5, 6
trechmanni, 45
Pseudorthoceras, 553
knoxense, 553, 227—1
Pseudosageceras, 581
intermontanum, 581, 239—12, 13
Pseudoschwagerina, 25
texana, 25, 4—28, 29
uddeni, 25, 4—25, 26
Pseudotorinia, euprepes, 491, 200—16–18
Pseudouvigerina, 35
plummerae, 35, 8—11
Pseudozygopleura, 461
kelletti, 461, 187—8
minuta, 461
schucherti, 461, 187—9
scitula, 461, 187—6, 7
semicostata, 461, 187—1, 2
wortheni, 461, 187—3–5
Psilaxis, krebsii lampra, 491, 200—19–22
Psiloconcha, 371
grandis, 371, 145—3, 4
Psioidea, 359
Ptarmigania, 609, 617
germana, 617, 258—13, 14
rossensis, 617, 258—6–8
Pteria, 391
gastrodes, 391, 152—10
limula, 391, 152—9
linguaeformis, 391, 152—6
longa, 391, 152—2
nebrascana, 391, 152—5
petrosa, 391, 152—3, 4
salinensis, 391, 152—8
submcconnelli, 391, 152—7
sulcata, 391, 152—1
Pteriacea, 383
Pterinea, 383, 385, 391
bisulcata, 369
concentrica, 409
demissa, 383, 148—16
fasciculata, 383
laevis, 383
lanii, 383, 148—17
modiolaris, 411
pygmaea, 393
radialis, 383
reversa, 403
Pterinocrinus, 187
quinquenodus, 187, 72—22
Pterinopecten, 403
princeps, 403, 160—3
rectilaterarius, 403, 160—4, 5
undosus, 403, 160—6–8
Pteris, 389
Pterocephalia, 631
sanctisabae, 631, 266—35–37
Pterocerella, 499
poinsettiformis, 499, 204—14, 15
Pterochaenia, 385
fragilis, 385, 149—16
Pteroconus, 241
gracilis, 241, 93—69
Pterocorallia, 83
Pteronites, 391
angustatus, 391
profundus, 391, 152—12
rostratus, 391, 152—11
Pteropoda, 366, 517
Pterotheca, 445
expansa, 445, 180—15, 16
saffordi, 445, 180—17, 18
Pterotocrinus, 199
bifurcatus, 199, 78—17
capitalis, 199, 78—16
Pterygocythereis, cornuta americana, 688, 289—40–43
Pterygota, 703
Pterygotus, 709
macrophthalmus, 709, 299—3, 4

Pterygotus, problematicus, 709
Ptilodictya, 267
flexuosa, 269
nebulosa, 267, 101—35
shafferi, 269
Ptilograptus, 67
plumosus, 67, 69, 20—22
Ptilopora, 265
cylindracea, 265, 100—19, 20
pluma, 265
striata, 265, 100—21
Ptomatis, 441
patulus, 441, 177—1–4
Ptychagnostus, 600
punctuosus, 600, 251—20
Ptychaspis, 625, 631
granulosa, 631, 262—18–21
miniscaensis, 631, 262—1
striata, 631, 262—2
Ptychocrinidae, 187
Ptychocrinus, 187, 70—9
splendens, 187, 72—19
Ptychoglyptus, 337
virginiensis, 337, 128—37, 38
Ptychomphalina, 457
Ptychonema, 449
Ptychoparella, 617
adamsi, 617, 259—10, 11
billingsi, 617, 259—9
brevicauda, 617
Ptychoparia, convexa, 609
laeviceps, 611
llanoensis, 629
metra, 627
pernasuta, 623
pero, 635
similis, 627
teucer, 605, 253—6
urania, 621
Ptychophyllum, 97
stokesi, 97, 31—15–17; 32—19, 20
Ptychopleura, 631
brevifrons, 631
Ptychopleurites, 631
brevifrons, 631, 266—9, 10
Ptychopteria, 391
salamanca, 391, 152—22
Ptychospira, 473
Ptychospirina, 473
varians, 475, 194—3–5
Pugnellus, 497
densatus, 497, 203—27, 28
fusiformis, 497, 203—30–32
Pugnoides, 315
calvini, 315, 120—13–17
duplicatus, 315, 120—18–21
ottumwa, 315, 120—22–26
Pullenia, 41
salisburyi, 41, 10—13
Pulmonata, 366, 519
Pulvinulina, arca, 43
erinacea, 37
menardii tumida. 43
reticulosa, 39
Pulvinulinella, 39
subperuviana, 39
texana, 41, 10—10
Punctospiracea, 283, 284, 359
Punctospirifer, 359, 361
kentuckiensis, 361, 141—6, 7
pulcher, 361, 141—8
scabricosta, 359
Pupillaria, 480
Pustulina, 319
pustulosa, 319, 121—33–37
Pustulopora, intricaria, 251
Pycnodonte, 397
radiata, 397
Pycnomphalus, 471
obesus, 471
solarioides, 471, 193—21–23
Pycnosaccus, 181, 66—1
patei, 181, 54—4
tenuibrachiatus, 181, 69—11
Pycnostylus, 103
Pygocaulia, 283, 284
Pygorhynchus, mortonis, 225
Pyrgoella, 29
sphaera, 29, 5—7, 8
Pyrgozyga, 461
Pyrgulifera, 489
humerosa, 489, 200—5–7
Pyropsis, 501
coloradoensis, 501, 206—8, 9
perlata, 501
proxima, 501, 206—10, 11
Pyrula, 500
Pyxiprimitia, 665
ventriclefta, 665, 281—8, 9

Q

Quinqueloculina, 27
moremani, 27, 5—4
secans, 27

R

Radiolaria, 12, 48
Radiolites, 421
davidsoni, 421, 168—16
Rafinesquina, 281, 337, 339, 106—9
alternata, 131
deltoidea, 337, 129—23
loxorhytis, 337, 129—19–22
nasuta, 337, 129—17, 18
ponderosa, 337
trentonensis, 337, 129—24
Ranapeltis, 682
trilateralis, 682, 286—45–47
typicalis, 682
Rapana, 505
stantoni, 505
Raphidodiscus, marylandicus, 301—31
Raphispira, 469
Raphistoma, 449
lapicida, 447
peracutum, 449, 181—17–20
stamineum, 449, 181—21–23
striatum, 449, 181—21–23
Raphistomina, 447
affinis, 447, 181—3, 4
lapicida, 447, 181—1, 2
Rattrayella, inconspicua, 301—33
Raymondatia, 669
goniglypta, 669, 281—58–60
Rayonnoceras, 555
solidiforme, 555, 228—5
Receptaculites, 57
neptuni, 57
occidentalis, 57, 17—24, 25
oweni, 57, 17—26
Rectogümbelina, 33
cretacea, 33, 8—3
Reedops, 653
deckeri, 653, 274—14, 15
Remopleurides, 653
canadensis, 653, 267—17–19
colbii, 653
Reniera, arca, 56, 16—30
phaseola, 56, 16—29
siliqua, 56, 16—28
Rensselaeria, 363, 364, 142—3, 4
claypolii, 364

Rensselaeria, elongata, 363, 142—1, 2
johanni, 364
marylandica, 363, 142—3, 4
ovoides gaspensis, 363
Rensselandia, 364
johanni, 364, 142—15
Reophax, 13
scorpiurus, 13
texana, 13, 1—6
Reptaria, 251
stolonifera, 251, 95—20, 21
Reptolunulites, 275
angulosa, 275
distans, 275, 104—1
verrucosa, 275, 104—9, 10
Requienia, carinata, 421
patagiata, 421, 168—1, 2
Resserella, 295, 351, 353, 355, 357
corpulenta, 353, 138—8, 9
fertilis, 353, 138—10
meeki, 353, 138—11–14
multisecta, 353, 138—15–18
rogata, 353, 138—6, 7
tersa, 353, 138—19, 20
Reteocrinidae, 183
Reteocrinus, 183, 187, 70—1
nealli, 183, 72—1, 8
stellaris, 183
Retepora, archimedes, 264, 100—3
diffusa, 261
pluma, 265
Reticularina, 361
spinosa, 361, 141—9–13
Retiolites, 75
geinitzianus, 75
geinitzianus venosus, 75, 22—15, 16
Retrorsirostra, 298
carleyi, 298, 111—49–51
Retzia, vera, 361
Reuschella, 355
edsoni, 355, 139—40–42
semiglobata, 355
Rhabdocyclus, 85
parvulus, 85, 23—11–14
Rhabdoliths, 12, 19, 14—11, 14
Rhabdospira, 475
Rhabdostropha, 461
Rhachopea, 445
Rhakistella, 55
alba, 55, 16—14
Rhapalonaria, tenuis, 250
venosa, 250, 95—1
Rhaphanocrinus, 183
sculptus, 183, 72—23
Rhaphoneis, angularis, 301—6, 7
Rhineoderma, 453
piasaense, 455, 183—30, 31
wortheni, 455, 183—29
Rhinidictya, 269
mutabilis, 269, 102—6, 7
nicholsoni, 269
Rhinocarina, 659
Rhinocaris, 659
capsella, 659, 279—35
columbina, 659
scaphoptera, 659, 279—34
Rhipidium, 305
knappi, 305, 115—29, 30
Rhipidomella, 353, 355
carbonaria, 355, 139—24–26
hybrida, 355, 139—5–7
missouriensis, 355, 139—11–15
musculosa, 355, 139—8–10
oblata, 355, 139—16, 17
oweni, 355, 139—18–20
penelope, 355, 139—21–23
Rhizocrinus, 205
alabamaensis, 205, 79—1
cylindricus, 205, 79—2
lofotensis, 205
Rhizophyllum, tennesseensis, 99, 32—17, 18
Rhodocrinites, 183, 185, 70—8
barrisi, 185, 73—7
cavanaughi, 185, 73—10
douglassi serpens, 185, 73—9
kirbyi, 185, 73—12
tuberculatus, 185, 73—6
verus, 185
watersianus, 185, 73—8
wortheni, 185, 73—11
Rhodocrinitidae, 185
Rhodophyta, 716
Rhombifera, 127
Rhombopora, 265, 267
crassa, 267, 101—7, 8
lepidodendroides, 265, 267, 101—4–6
tenuirama, 267, 101—9–11
Rhombotrypa, 258
quadrata, 258, 97—24, 25
Rhopalithes, 501
Rhopalonaria, 250
Rhynchocamera, 303
Rhynchonella, aequiplicata, 365
eurekensis, 315
glansfagea, 363
guadalupae, 315
heteropsis, 311
increbescens, 309
missouriensis, 313
ottumwa, 315
peregrina, 315
reticulata, 307
speciosa, 311
whitii praecursor, 309
Rhynchonellacea, 283, 284, 307
Rhynchopora, 315, 359
magnicosta, 359, 140—27–30
taylori, 359, 140—24–26
Rhynchospira, evax, 361
nobilis, 311
Rhynchospirina, 281, 361
formosa, 361, 141—14–18
Rhynchotrema, 309, 118—17, 18
argenturbicum, 309, 118—4–6
capax, 309, 118—7–10
dentatum, 309, 118—11–13
increbescens, 309, 118—14–16
minnesotense, 309, 118—19–22
perlamellosum, 309, 118—29–30
Rhynchotreta, 309
americana, 309, 118—23–25
Rhytimya, 414
producta, 414, 165—6
radiata, 414, 165—5
Rhytistrophia, 341
beckii, 341, 131—26-28
Ribeiria, 659
calcifera, 659, 297—17–19
nuculitiformis, 659, 297—20–22
pholadiformis, 659
Richardsonoceras, 557
simplex, 557, 228—19, 20
Richteria, 687
serratostriata, 687, 289—7, 8
Rictaxis, 515
punctocoelatus, 515, 212—12, 13
Rimella, 497
Ringicula, 515
buccinea, 515
dalli, 515, 212—5, 6
pulchella, 515, 212—3, 4
Robulus, 31

Robulus, cultratus, 31
navarroensis, 31, 6—3
Roemerella, 291
grandis, 291, 109—25, 26
Romingeria, 113
umbellifera, 113, 40—10, 11
Rosenella, 63
Rostellaria, americana, 497
velata, 499
Rostricellula, 307
ainsliei, 309, 118—1–3
plena, 309, 117—25–29
rostrata, 307, 309, 117—34–40
Rostrospiracea, 283, 329
Rotalia, 39
byramensis, 39, 9—9
exsculpta, 39
trochidiformis, 39
Rotalina, contraria, 39
Rotellomphalus, 447
Roubidouxia, 447
depressa, 447, 180—7
umbilicata, 447, 180—6
Rudistacae, 421
Rudistae, 421
Ruedemannia, 449
Rustella, 284, 293
edsoni, 293, 110—4
Rutilaria, epsilon, 301—27
Ryticeras, 545
jason, 545, 222—15
trivolve, 545, 222—16–18
Rzehakina, 27
epigona lata, 27, 5—1

S

Saccelatia, 665
arrecta, 665, 280—38–40
Saccella, gabbi, 377, 146—32
parva, 377, 146—28
Saccocrinus, 191, 71—1
benedicti, 191, 75—17
speciosus, 191
Sactoceras, 555
josephianum, 555, 227—9, 10
Saffordella, 473
Saffordia, 371
modesta, 371, 144—31, 32
ventralis, 371, 144—33, 34
Sagenites, 581
herbichi, 581, 239—14–16
Sagenocrinites, 179, 67—7
americanus, 179, 54—11
clarki, 179, 54—10
Sagenocrinitidae, 179
Sagenocrinoidea, 179
Sagrina, rugosa, 18
Salenia, 219
texana, 219, 226, 89—4, 5
Salpingostoma, 441
buelli, 443, 177—14–16
richmondense, 443, 177—17, 18
Salterella, 531
billingsi, 533, 217—1
curvata, 531, 217—3
pulchella, 531, 217—4
rugosa, 531, 217—2
Sanguinolites, 414
arcaeformis, 414
Sansabella, 679
amplectans, 679, 285—5–7
bradfieldi, 679, 285—8–13
Saracenaria, 32
italica, 32, 6—9
Sarcodina, 11, 12
Sargana, 505
Sargana, stantoni, 505, 207—8, 9
Sarocrinus, 167
Saukia, 631, 633
acuta, 633, 260—30
lodensis, 631
pepinensis, 633
Saukiella, 633
pepinensis, 633, 260—31–37
typicalis, 633, 260—26–29
Savagella, 673
lindahli, 673, 283—8, 9
Saxicava, 431
arctica, 431, 172—15, 16
rugosa, 431
Scaevogyra, 439
swezeyi, 439, 175—21–23
Scala, 481
Scalaria, 481
pretiosa, 481
Scalaripora, 270
scalariformis, 270, 102—11
Scalarituba, 234
missouriensis, 234
welleri, 234, 92—31, 32
Scalez, 487
petrolia, 487, 199—18, 19
Scaliognathus, 245
anchoralis, 245, 94—37, 38
Scalpellum, 695
Scambula, 419
perplana, 419, 167—6, 7
Scaphiocrinus, aequalis, 161
robustus, 169
rusticellus, 159
scalaris, 169
Scaphites, 589
aequalis, 589
hippocrepis, 591, 244—4, 5
tridens, 591
ventricosus, 591, 244—10
warreni, 591, 244—6
Scaphopoda, 366, 521, 525
Scenella, 437
acadica, 437, 175—1, 2
reticulata, 437, 175—3
Sceptroneis, caducea, 301—28
Schackoina, 41
multispinata, 41, 11—5, 6
Schistoceras, 573
hildrethi, 573, 235—11, 12
missouriense, 573, 235—9, 10
Schistocrinus, 165
confertus, 165, 64—32
parvus, 165, 64—27
torquatus, 165, 62—12; 64—8
Schizambon, 287
typicalis, 287, 108—21–24
Schizobasis, 480
depressa, 480, 197—4, 5
Schizoblastus, 134, 135, 137
etheridgei, 135, 51—24–26
sayi, 137, 51—17–23
Schizobolus, 291
concentricus, 291, 109—19–21
Schizocoralla, 101
Schizocrania, 291
filosa, 291, 109—16–18
Schizodiscus, 660
capsa, 660, 279—7–9
Schizodonta, 366, 383
Schizodus, 401
chemungensis, 401, 159—2
cuneatus, 401, 159—3
schlotheimi, 401
wheeleri, 401, 159—1, 4
Schizopea, 445

Schizopea, typica, 447, 180—12–14
washburnei, 445, 180—11
Schizophoria, 283, 357, 106—1, 2; 140—4, 5
australis, 357, 139—54–56
iowensis, 140—4, 5
macfarlani, 357, 140—1–3
multistriata, 357, 140—10, 11
nevadaensis, 357, 140—6, 7
swallovi, 357, 140—8, 9
Schizoporella, informata, 275, 104—8
Schizostoma, 465
Schmidtella, 664
crassimarginata, 664, 280—35–37
Schroederoceras, 541
eatoni, 543, 221—11
Schuchertella, 343
desiderata, 343, 132—46–48
lens, 343
perversa, 343, 132—43–45
woolworthana, 343, 132—49–51
Schuchertoceras, 537
anticostiense, 537, 218—16
Schultzicrinus, 154
typus, 154, 57—5, 6
Schwagerina, 23, 25, 27
compacta, 27
emaciata, 25, 4—27, 33
fusulinoides, 25
gigantea, 25
huecoensis, 25, 4—18–20
linearis, 27
setum, 25, 4—13–15
uddeni, 25
Sciadiocrinus, 165
acanthophorus, 165, 62—11; 64—1
disculus, 165, 64—7
harrisae, 165, 62—17; 64—6
Scobinella, 513
claytonensis, 513, 210—33, 34
coelata, 513, 210—32
Scolithus, 234
clintonensis, 234, 92—33
linearis, 234, 92—34
verticalis, 234, 92—35
Scolopodus, 240
quadruplicatus, 240, 93—38, 39
semicostatus, 240, 93—27
sublaevis, 240
Scutella, 221, 223
aberti, 221, 85—13–15
coosensis, 223
excentrica, 223
lyelli, 221
mississippiensis, 221
parma, 223
quinquefora, 223
Scutellum, 653
acamas, 653, 269—17
barrandi, 653, 269—16
costatum, 653
lunatum, 653, 269—15
Scyphocrinus, 209
heterocostalis, 155
Scyphozoa, 58, 77
Scytalocrinidae, 167, 52—17
Scytalocrinus, 169
validus, 169, 59—11
Sedentaria, 231
Sellardsicrinus, 175
marrsae, 175, 64—29
Semele, 429
rubropicta, 429, 171—8
subovata, 429, 171—9
Semicoscineum, 263
planodorsatum, 263, 99—31
rhomboideum, 263
Semicoscineum, tenuiceps, 263, 99—32
Seminola, 503
crassa, 503, 207—17, 18
Seminolites, 683, 685
sohni, 683, 287—7, 8
truncatus, 683, 287—9
Sepioidea, 366, 597
Septastrea, 121
marylandica, 121, 44—17, 18
subramosa, 121
Serpula, 231
arenaria, 491
dianthus, 231
lumbricalis, 491
pervermiformis, 231, 92—12
seminulum, 27
spirorbis, 231
spirulaea, 233
sulcata, 32
vermicularis, 231
Serpularia, 465
centrifuga, 465
Serpulites, 77, 79
angustifolius, 79, 23—3
longissimus, 79
Serpulospira, 465
laxus, 465, 188—2
paradoxus, 465, 188—9
Sertularia eburnea, 250
Setigerites, 350
setigerus, 350, 136—23–25
Sevillia, 653
sevillensis, 653, 276—14–16
Seymourites, 587
loganianus, 587, 242—13
Shansiella, 457
altispiralis, 457
carbonaria, 457, 185—8
planicostata, 457, 185—9, 10
Shumardella, 313
missouriensis, 313, 119—27–30
Shumardia, 653
granulosa, 653, 267—8, 9
Shumardites, 575, 577
simondsi, 575, 236—16–19
Sibrites, kingianus, 579
Siderolina cenomana, 41
Sidneyia, 655
inexpectans, 655, 279—36
Sieberella, 305
roemeri, 305, 115—12, 13
Sigaretopsis, 483
Sigaretus, 473, 481
Sigmacystis, 125
Sigmomorphina, 32
frondicula riformis, 32, 7—4
yokoyamai, 32
Silicina, epigona, 27
Silicispongiae, 49, 51
Silicoflagellata, 11
Silicosigmoilina, 27
californica, 27, 5—2, 3
Simoceras agrigentium, 587
Sinuites, 441
cancellatus, 441, 176—24, 25
rectangularis, 441, 176—21–23
Sinum, 481
bilix, 481, 198—4
fragile, 481, 198—1, 2
scopulosum, 481, 198—3
Sinuopea, 447
regalis, 447, 180—9
sweeti, 447, 180—10
vera, 447, 180—8
Sinuspira, 457
Sinutropis, 465

Sinutropis, esthetica, 465
fairchildi, 465, 189—12, 13
Siphogenerina, plummeri, 35
Siphogenerinoides, 35
plummeri, 35, 8—12
Siphonia, cratera, 53
praemorsa, 53
Siphonina, 39
fimbriata, 39
howei, 39, 10—3
Siphoninella, 39
claibornensis, 39, 10—4
Siphonocrinus, 187
nobilis, 187, 72—21
Siphonodella, 245
duplicata, 245
lobata, 245, 94—55
quadruplicata, 245, 94—44, 45
Siphonodentaliidae, 523
Siphonognathus, 245
duplicata, 245
Siphonophora, 58
Siphonophrentis, 93
gigantea, 93, 28—25, 26, 30, 31
Siphonotretacea, 283, 287
Sipunculoidea, 228, 234
Sismondia alta, 221
Skenidioides, 301
billingsi, 301, 113—1–6
Skenidium, 301
insigne, 301, 113—7–12
Skolithos, 234
Solarium, 489
Solemya, 369
mediterranea, 369
vetusta, 369, 144—1, 2
Solenacea, 429
Soleniscus, 479
typicus, 479, 196—15, 16
Solenochilus, 549
collectus, 549, 224—14, 15
Solenodella, 244
bialata, 244, 94—6
fulcrata, 244, 94—5
lacerata, 244, 94—4
Solenognathus, 244
lacerata, 244
Solenopleura, grönwalli, 615
jerseyensis, 635
Solenopleurella, 617
buttsi, 617, 255—22
ulrichi, 617
Solenopora, 715, 717
compacta, 717, 302—31; 303—30–32
jurassica, 302—30, 32
spongioides, 717
Solenospira, 459
Sowerbyella, 335
clarkesvillensis, 335, 128—39, 40
punctostriata, 335, 128—44–49
rugosa, 335, 128—41–43
Sowerbyites, 335, 337
medioseptata, 335
triseptatus, 335, 128—25-28
Spandelina, 17
excavata, 17, 2—5
Spaniocrinidae, 173
Spatangus, bufo, 225
coranguinum, 226
Spathella, 414
typica, 414, 165—7
Spathiocaris, 659
emersoni, 659
woodfordi, 659, 279—25–29
Spathodus, 244
primus, 244
Spathognathodus, 244
primus, 244
regularis, 244, 94—1
sulciferus, 244, 94—2
Sphaerechinus, granularis, 89—24
Sphaerexochus; 653
mirus, 653
parvus, 653, 272—16
romingeri, 653, 272—17–22
Sphaerium, 419
formosum, 419, 167—8, 9
formosum, whiteavesi, 419
planum, 419, 167—10
Sphaerocyclus, 443
Sphaerocystites, 128
multifasciatus, 128, 48—7, 8
Sphaerodoma, 479
Sphaeropthalmus, 623, 633
fletcheri, 633, 262—3–6
pecten, 623
Sphaerotocrinus, 185
ornatus, 185, 72—74
Sphenodiscus, 595
lenticularis, 595, 248—10–12
lobatus, 595, 248—7
pleurisepta, 595, 248—8, 9
Sphenotus, 414
contractus, 414, 165—4
truncatus, 414, 165—3
Sphyradoceras, 557
clio, 557, 228—8, 9
Spinocyrtia, 282, 323
granulosa, 323, 123—6–8
Spirifer, 299, 325, 359
ambiguus, 335
anosoffi, 321
arkansanus, 325, 124—23, 24
bifurcatus, 325, 124—10–13
carinatus, 323
crispus, 327
cultrijugatus, 323
fasciger, 325
gregarius, 323
grimesi, 325, 124—25–27
increbescens, 325, 124—6–9
keokuk, 325, 124—14–17
lamellosus, 271
lateralis, 325, 124—1–5
multistriatus, 361
neglectus, 359
orestes, 325, 124—18, 19
pennatus, 321
planicostatus, 323
primaevus, 323
pseudolineatus, 327
pyxidatus, 329
radiatus, 319
rockymontanus, 325, 124—20–22
spinosa, 361
tenticulum, 321
urei, 329
ventricosa, 331
venustus, 323
verneuili, 321
Spirifera, macbridei, 325
ovalis, 327
Spiriferacea, 283, 284, 317
Spiriferina, suessi australis, 359, 140—52–55
Spirillina, 37
vicksburgensis, 37, 9—6
vivipara, 37
Spirocyathus, 56
Spirolina, aequalis, 15
agglutinans, 15
Spiroloculina, 27
depressa, 27

Spiroloculina, wilcoxensis, 29, 5—6
Spirophyton, 719
Spiroplectammina, 17
castensis, 17, 2—1
Spiropora, 251
elegans, 251
majuscula, 251, 96—1
Spiroraphe, 455
Spirorbis, 231
angulatus, 231
annulatus, 233, 92—8
anthracosia, 233, 92—9, 10
arkonensis, 233, 92—5, 6
calvertensis, 233, 92—11
laxus, 231, 92—1-4
nodulosus, 233
omphalodes, 233, 92—7
Spirula, 529
Spisula, 431
albaria, 431, 171—16
Spiticeras, 589
uhligi, 589, 244—11, 12
Spondylospira, 359
alia, 359, 140—48-51
reesidei, 359, 140—43-47
Spondylus, 368
plicatus, 407
Spongiostroma, 715
Sporadoceras, 567
milleri, 567, 232—5-7
Sporozoa, 11
Springericrinus, 157
doris, 157, 58—12
magniventrus, 157, 58—9, 19
Spyroceras, 541
bilineatum, 541, 221—3
crotalum, 541, 221—2
nuntium, 541, 221—4, 5
olorum, 541, 221—6
ruedemanni, 541
thoas, 541, 221—7
Squama, 695
Stacheoceras, 575, 577
mediterraneum, 577
rothi, 577, 236—23
Stachyodes, 63
Staffella, 19, 21
hollingsworthi, 21, 3—39-43
Staurognathus, 244
cruciformis, 244, 94—19
Staurograpsus, dichotomus, 69
Staurograptus, 69
dichotomus, 69, 21—10
Staurospira, 469
Stearoceras, 545
Steganocrinus, 193, 71—12
pentagonus, 193, 77—6
sculptus, 193, 77—5
Steganoporella, 275
vicksburgica, 275, 104—6
Stegerhynchus, 309
acinus, 309, 118—34-37
indianense, 309, 118—26-28
neglectum, 309, 118—38-40
whitii, 309, 118—31-33
Stegocoelia, 459
compacta, 459
illinoiensis, 459, 185—18
turritella, 459, 185—19
wortheni, 459, 185—20
Stellarocrinus, 157
florealis, 157, 60—14
geometricus, 157, 58—5
stillativus, 157, 57—13
Stellaxis, alveata, 489, 200—13, 14
cognata, 491, 200—15
Stelleroidea, 123, 211
Stenaster, 211
salteri, 211, 81—1
Stenhoplites, 589
Stenopilus, 633
latus, 633, 260—8, 9
pronus, 633, 260—10, 11
Stenopoceras, 549
abundum, 549, 224—16, 17
Stenopora, 259
Stenoscisma, 315
explanata, 315, 120—41-45
kernahani, 315, 120—46-48
venusta, 315, 120—38-40
Stenotheca, 701
abrupta, 701, 297—2-4
cornucopia, 701
curvirostra, 701, 297—5
levis, 701, 297—6
rugosa, 701, 297—9-14
Stensiöina, 39
excolata, 39, 9—5
Stephanodiscus, astraea, 301—41
Stephanograptus, 71
Stephanozyga, 461
nodosa, 463, 187—13
subnodosa, 463, 187—12
Stereobrachicrinus, pustullosus, 209, 79—12
Stereoconus, 237
gracilis, 237, 93—16, 21
Stereocrinus, 201, 70—18
helderbergensis, 201
indianensis, 201
triangulatus, 201, 74—23
Stereolasma, 87
rectum, 87, 24—17-22
Sthenorytis, pachypleura, 481, 197—29
Stibus, 682
kothornostibus, 682, 286—32-36
Stictodiscus, californicus, 301—24
Stictopora, shafferi, 269
Stictoporella, 269
cribrosa, 269, 101—36, 37
interstincta, 269
Stictotrypa, 271
punctipora, 271, 103—5, 6
similis, 271
Stinocrinus, 158
granulosus, 158
manus, 159, 60—15
Stomatopora, 250
pratti, 250, 95—10
Stramentum, 695
Straparollina, 469
eurydice, 469, 192—14, 15
pelagica, 469, 192—12, 13
Straparolus, 463
catilloides, 465, 188—23-25
cyclostomus, 465, 188—3-5
dionysii, 463
latus, 465, 188—15
laxus, 465, 188—2
muricatus, 465, 188—40-42
paradoxus, 465, 188—9
pernodosus, 465, 188—20-22
planidorsatus, 465, 188—13, 14
plummeri, 465, 188—32, 33
reedsi, 465, 188—26-28
rudis, 465, 188—1
savagei, 465, 188—16, 17
similis, 465, 188—10-12
spergenensis, 465, 188—6-8
subquadratus, 465, 188—29-31
subrugosus, 465, 188—34-39
umbilicatus, 465, 188—18, 19
Streblites, 583

Streblites, uhligi, 583, 240—15, 16
Streblotrypa, 267
hamiltonensis, 267, 101—13, 14
nicklesi, 267, 101—15-17
Strenuella, 617
strenua, 617, 253—18
Strepsidura, 501
ficus, 501, 205—21
turgidus, 501
Streptacis, 463
scalpta, 463, 187—20, 21
whitfieldi, 463, 187—22-24
Streptelasma, 83, 85
corniculum, 85, 24—1-3
petoskeyense, 85, 24—4-7
rectum, 87
rusticum, 85, 24—8-10
stricta, 85
Streptocrinus, 155
Streptognathodus, 246
elegantulus, 246
excelsus, 246, 94—73, 74
gracilis, 246, 94—72
Streptorhynchus, lens, 343
Strepula, sigmoidalis, 681
Striacoceras, 539
typum, 539, 220—6, 7
Striatopora, 109
bellistriata, 111, 39—7
flexuosa, 109, 39—5, 6
iowensis, 109, 39—8
rugosa, 111
Stricklandia, 307
castellana, 307, 117—5, 6
gaspiensis, 307, 117—48
triplesana, 307, 117—1-3
Strigogoniatites, 575
Stringocephalus, 364
burtini, 364, 143—4, 5
Strioterebrum, dislocata, 511, 210—18
Strobeus, 479
littonanus, 479, 196—13
medialis, 479, 196—14
paludinaeformis, 479, 196—9
primogenius, 479, 196—10, 11
regularis, 479, 196—12
subcostatus, 479, 196—8
ventricosus, 479
Strobilepis, 695
spinigera, 695, 293—9-12
Stroboceras, 545
trisulcatum, 545, 223—2, 3
Stromatocerium, 63
huronense, 63, 19—11
rugosum, 63, 19—12, 13
Stromatocystites, 129
pentangularis, 129
walcotti, 129, 49—11
Stromatolith, 715
Stromatopora, 59, 61
antiqua, 1, 61, 19—1, 2
concentrica, 59, 61
constellata, 61, 19—5
Stromatoporella, 61
granulata, 61, 18—16
tuberculata, 61, 18—21, 22
Stromatoporoidea, 58, 63
vera, 59
Stromatotrypa, 259
ovata, 259, 99—12, 13
Strombiformis, reticulatus, 495
Strombodes, 101
murchisoni, 101
rectus, 87
Strombus, 499
aldrichi, 499, 204—1, 2
Strombus, cannalis, 497
chipolanus, 499, 204—3, 4
densatus, 497
pugilis, 499
pugiloides, 499
Strophalosia, scintilla, 349
Strophalosina, 349
magnicostata, 349, 135—38-40
Stropheodonta, 282, 339, 341
demissa, 339, 131—12-14
erratica, 339, 131—5, 6
filifer, 341
Strophodonta, beckii, 341
concava, 339
magnifica, 341
nacrea, 341
reversa, 339
Strophomena, 129, 282, 297, 337, 339, 343
alternata, 337
blainvillii, 341
carinata, 359
deflecta, 297
demissa, 339
leda, 339
nacrea, 341
neglecta, 337, 130—11-14
nervosa, 341
nutans, 337, 130—8-10
planoconvexa, 337, 130—1-5
planumbona, 337, 130—21-24
tennesseensis, 337, 130—15-18
vicina, 337, 130—6, 7
Strophomenacea, 283, 284, 335
Strophonella, 339
ampla, 339, 130—25-28
punctulifera, 339, 130—19, 20
semifasciata, 339
Strophonelloides, 339
reversus, 339, 131—7-11
Strophostylus, 475
andrewsi, 475, 194—12
girtyi, 475, 194—8-11
gregarius proeva, 473
Strotocrinus, 193, 71—14
glyptus, 193, 77—9
Stuartwellercrinus, 175
symmetricus, 175, 60—19
Stylarea, 105
Styliolina, 517, 526
fissurella, 526, 215—53
Styliolinidae, 77
Stylodictyon, 61
columnare, 61, 18—23, 24
Stylonurus, 707
cestrotus, 709, 299—7
powriei, 707
Stylopoma, 275
spongites, 275, 104—8
Subbryantodus, 244
arcuatus, 244, 94—9
Subrensselandia, 364
claypolii, 364, 142—8, 9
Subretepora, 261
asperato-striata, 261, 99—19, 20
reticulata, 261, 99—21
Substeueroceras, 587
kellumi, 587, 242—16, 17
Subulites, 477
elongatus, 477, 195—26
inflatus, 477, 195—19
nanus, 477, 195—25
regularis, 477, 195—27
subbrevis, 477, 195—18
subelongatus, 477, 195—26
terebreviformis, 477, 195—17
tortilis, 477, 195—16

Subulites, ventricosus, 477, 195—19, 21
Sulcatostrophia, 341
camerata, 341, 131—20, 21
Sulcella, 685
sulcata, 685, 288—24
Sulcocypraea, 500
lintea, 500, 205—7, 8
Sulcoretepora, 270
gilberti, 270, 102—15
incisurata, 270, 102—16, 17
Sulcosipho, tabulata, 505, 207—7
Surcula, 514
Surculites, 514
annosus, 514
sinuatus, 514, 211—13–15
Surirella, oblonga, 301—20
Sycidium, 713
foveatum, 716, 303—3
reticulatum, 713
Sycotypus, 503
canaliculatus, 503
excavatus, 503, 206—21
ocoyanus, 500
rugosus, 503, 206—22, 23
Sygcaulocrinus, 145, 52—7
typus, 145, 52—7
Symbols, crinoid, 141, 142, 143
Synaptocrinus, 183, 66—10
nuntius, 183, 68—7
Synaptophyllum, 95, 99
arundinaceum, 95, 30—5–7
multicaule, 95, 29—25–28
simcoense, 95, 30—1–4
Synbathocrinidae, 151
Synbathocrinus, 151, 52—10
conicus, 151
dentatus, 151, 55—16
matutinus, 151, 56—22
robustus, 151, 55—11; 56—23
sulcatus, 151, 56—17
wachsmuthi, 151, 55—10
Syncarida, 697
Syncyclonema, 405
halli, 407, 161—15, 16
Syndetocrinus, 153
Synerocrinidae, 179
Synerocrinus, 179, 67—3
formosus, 179, 56—20
Synphoria, 637, 641, 649, 653
stemmatus, 653, 273—1, 2
Syntrophia, 303
campbelli, 301
lateralis, 303, 114—29–31
orthia, 301
texana, 301
Syntrophiacea, 283, 284, 301
Syntrophina, 301
campbelli, 301, 114—20–23
convexa, 301
Syntrophopsis, 303
magna, 303, 114—32–35
obscura, 303
Syringopora, 83, 115
aculeata, 115, 42—11, 12
hisingeri, 115, 42—1, 2
multattenuata, 115, 42—5–9
perelegans, 115, 42—10
ramulosa, 115
retiformis, 115, 41—20
surcularia, 115
tabulata, 115, 42—3, 4
verticillata, 115, 41—21
Syringoporidae, 105
Syringospira, 327
alta, 327, 125—15–17
prima, 327, 125—12–14
Syringostroma, 61
barretti, 61, 19—3, 4
densum, 61
niagarense, 61, 19—9, 10
Syringothyris, 327, 363
texta, 363, 142—27–29
typa, 363

T

Tabulata, 105
Tabulipora, 259
carbonaria, 259, 98—8, 9
scotica, 259
urei, 259
Tabulophyllum, 95
rectum, 95, 97, 31—1–4
Taeniaster, 213
spinosus, 213, 81—8
Taenicephalus, 633
shumardi, 633, 266—17
Taeniopora, 270
exigua, 270, 102—25, 26
Tainoceras, 547
nodocarinatum, 547
quadrangulum, 547, 223—14
Talanterocrinus, 181, 67—6
jaekeli, 181
mcguirei, 181, 56—30
Talarocrinus, 199
cornigerus, 199, 78—12
ovatus, 199, 78—11
Talbotina, 633
degrasensis, 633, 266—29–31
solitaris, 633, 266—32
Tanaocrinidae, 189
Tanaocrinus, 189
typus, 189, 72—3
Tancredia, 421
americana, 423, 168—20
bulbosa, 423, 168—21
donaciformis, 421
Taonurus, 719
caudagalli, 719, 303—23, 24
velus, 719, 303—25
Taphrognathus, 246
varians, 246, 94—66–68
Taras, 423
acclinis, 423, 168—29, 30
antiquatus, 423
hopkinsensis, 423, 168—31, 32
parilis, 423, 168—33
Tarphyceras, 541
multicameratum, 541, 221—10
prematurum, 541
seelyi, 543
Taxioura, 617
typicalis, 617, 259—23, 24
Taxocrinidae, 177
Taxocrinoidea, 177
Taxocrinus, 177, 179, 67—10
affinis, 177
colletti, 177, 69—5
expansus, 177
giddingsei, 177, 69—13
huntsvillae, 177, 69—16
intermedius, 177, 69—1
ornatus, 177, 69—9
ovalis, 177
telleri, 177, 68—5
whitfieldi, 177, 69—6
Taxodonta, 366, 373
Technocrinus, 200
andrewsi, 200, 74—8
Tectibranchiata, 366, 515
Tectonatica, clausa, 485, 199—1
Tegminal, expansus, 209, 79—17

Teguliferа, deformis, 351
Teguliferina, 351
armata, 351, 137—29, 30
Teleiocrinus, 193, 71—13
rudis, 193, 77—11
umbrosus, 193, 77—1
Teleodesmacea, 366, 415
Telephus, 653
bicornis, 654, 267—24-26
fractus, 653
Tellerina, 621, 633
crassimarginata, 633, 261—5, 6
Tellina, 368, 427, 429
cornea, 419
cuspidata, 415
declivis, 429, 170—27
equilateralis, 429, 170—22
eufaulensis, 429
fluminalis, 419
radiata, 427
reticulata, 429
soledadensis, 429, 170—23
undulifera, 429, 170—26
williamsi, 429, 170—24, 25
Tellinacea, 427
Tellinimera, 429
eborea, 429, 171—6, 7
Tellinomya, nasuta, 373
Tellinopsis, 371
subemarginata, 371, 145—11
Telotremata, 283, 284
Temnocheilus, 545, 547
coronatus, 547
winslovi, 547, 224—1, 2
Tenea, 423
parilis, 423, 169—1
Tentaculites, 523, 526
attenuatus, 526, 214—47
bellulus, 526, 214—43, 44
gracilistriatus, 526
gyracanthus, 526, 214—41, 42
scalariformis, 526, 214—45, 46
scalaris, 526
Tentaculitidae, 77
Tenticospirifer, 321
cyrtiniformis, 321, 121—41-44
utahensis, 321, 121—45, 46
Terataspis, 654
grandis, 654, 270—30
Terebra, 511
curvilineata, 511
curvilineata calvertensis, 511, 210—21
curvilineata dalli, 511, 210—19
curvilineata whitfieldi, 511, 210—22, 23
curvilirata, 511, 210—20
dislocata, 511, 210—18
sinuosa, 461
unilineata, 511, 210—24, 25
Terebratalia, 365
transversa, 365, 143—50, 51
Terebratella, 283, 365, 106—16
obsoleta, 365
Terebratula, 106—19
concentrica, 333
cuneata, 309, 365
geinitziana, 359
harlani, 365
hemisphaerica, 365
herculea, 331
lima, 365
michelini, 355
mormoni, 363
plicata, 365
rectirostra, 364
schlotheimii, 315
subwilsoni, 313
Terebratulacea, 283, 284
Terebratulina, 283, 365, 106—15
filosa, 365, 143—41
floridana, 365, 143—1-3
Terebratulites, biforatus, 299
elongatus, 364
Terranovella, 635
obscura, 635, 266—23
Tessarolax, 499
distorta, 499, 204—12, 13
Tetrabranchiata, 528
Tetracoralla, 81, 83
Tetractinellida, 49, 51, 56
Tetradella, 667
cicatricosa, 667
lunatifera, 667, 281—39-43
quadrilirata, 667, 281—44, 45
Tetradium, 101
carterense, 105
cellulosum, 101, 34—9-11
fibratum, 101, 103, 34—12-16
syringoporoides, 103
Tetragamma, streeruwitzi, 226, 88—5-7
Tetragonis, murchisoni, 57
Tetragraptus, 1, 69, 70
crucialis, 69
quadribrachiatus, 70, 21—5
similis, 70, 21—6
Tetralichas, 637, 649, 654
clermontensis, 654, 270—6
jukesi, 654, 270—7, 8
minganensis, 654, 270—13, 14
trentonensis, 654, 270—9, 10
Tetralobula, 301
delicatula, 301, 114—16-19
Tetranota, 441
bidorsata, 441, 177—19
obsoleta, 441, 177—20, 21
sexcarinata, 441, 177—9-11
Tetraseptata, 83
Tetrataxis, 31
conica, 31
scutella, 31, 5—20
Tetratylus, 683
ellipticus, 683, 287—12-14
Texacrinus, 161
Texanites, 593
Textularia, 17
agglutinans biformis, 17
cuneiformis, 17
globulosa, 33
quadrilatera, 33
ripleyensis, 17, 2—2
sagittula, 17
tricarinata, 18
Thalamocrinus, 153
ovatus, 153, 54—24
Thaleops, 654
ovata, 654, 268—11-15
Thallocrinidae, 201
Thallograptus, 67
phycoides, 67, 20—20
Thamnasteria, 117
rectilamellosa, 117, 42—20
Thamnidia, 715
Thamniscus, 264
furcillatus, 264, 100—17, 18
Thamnobeatricea, 61, 63
parallela, 63
Thamnocrinus, 191, 70—13
springeri, 191, 73—17
Thamnopora, 109
carbonaria, 109, 38—8, 9
madreporacea, 109
Theca, primordialis, 525, 215—45, 46
Thecia, 109

Thecia, major, 109, 39—1, 2
minor, 109
Thecocystis, 129
Thecosmilia, 117
fenestrata, 117, 43—32, 33
Theodossia, 321
hungerfordi, 321, 121—50, 51
Thetidicrinus, 154
Thlipsura, 681, 682
confluens, 682, 286—14–16
corpulenta, 681
furca, 682, 286—12, 13
Thlipsurella, 682
ellipsoclefta, 682, 286—19–21
secoclefta, 682, 286—17, 18
Tholiasterella, trunca, 56, 16—17, 18
Tholocrinus, 167
spinosus, 167, 59—2
wetherbyi, 167, 59—4
Thomasatia, 669
falcicosta, 669, 281—53
Thompsonaspis, 617
obscura, 617, 256—8–10
Thracia, 415
corbuloides, 415
trapezoides, 415, 165—24, 25
Thylacocrinus, 185
clarkei, 185, 72—27
vannoiti, 185
Thysanopeltis, 653
Tiarasmilia, 121
casteri, 121, 45—22, 23
Timorites, 577
curvicostatus, 577
uddeni, 577, 237—2, 3
Tirolites, 579
foliaceus, 579, 238—8–10
Titanoceras, 547
ponderosum, 547, 224—56
Titusvillia, 55
drakei, 55, 16—5
Tolypammina, 15
delicatula, 15, 1—10
grahamensis, 29
Tomagnostus, 600
fissus, 600, 251—7, 8
Tonkinella, 617
flabelliformis, 617
stephensis, 619, 259—27, 28
Torellellidae, 77
Tornatella, punctocoelata, 515
Tornatellaea, 515
bella, 515, 212—15
cretacea, 515, 212—10, 11
pinguis, 515
Tornoceras, 567
discoideum, 567, 231—14, 15
uniangulare, 567, 231—12, 13
Tortilla, 469
Tortophyllum, 93
cysticum, 93, 29—1, 2
Torynifera, 327
criticus, 327
pseudolineata, 327, 126—4–8, 16, 17
setigera, 327, 126—13–15
Tostonia, 635
iole, 635, 266—18, 19
Toucasia, 421
patagiata, 421, 168—1, 2
texana, 421, 168—3–5
Trachyceras, 579, 581
beckeri, 579
californicum, 579
chiesense, 579
cuccense, 579
lecontei, 579
Trachyceras, lindgreni, 579
madisonense, 579
shastense, 579, 238—21–23
Trachydomia, 475
newelli, 475, 194—31, 32
nodosa, 475, 194—33–35
nodulosa, 475, 194—29, 30
oweni, 475, 194—27, 28
sayrei, 475, 194—25, 26
Trachyodon, 527
eocenensis, 527, 216—15, 16
Trachypora, 109
austini, 109, 38—18–20
davidsoni, 109
elegantula, 109, 38—16, 17
ornata, 109, 38—21, 22
Trachysagenites, 581
herbichi, 581, 239—14–16
Trechmannia, 457
Tremanotus, 435, 443
alpheus, 443, 178—1, 2
Trematis, 289
millipunctata, 289, 109—9–12
pannulus, 287
terminalis, 291, 109—13–15
Trematoceras, 539
ohioense, 539
Trematopora, 261
granistriata, 267
tuberculosa, 261, 99—14–16
Trematospira, 361, 141—31
camura, 361, 141—19, 20
gibbosa, 361, 141—21–24
multistriata, 361, 141—28–30
Tremotoichos, 275
rectiforcatum, 275, 104—14
Trepospira, 453
discoidalis, 453, 183—21–23
rotalia, 453, 183—16–18
sphaerulata, 453, 183—19, 20
Trepostomata, 249, 255, 261
Tretaspis, 654
reticulata, 654, 267—39–41
Tretocycloecia, 251
tortilis, 251, 96—2, 3
Triarthropsis, 635
nitida, 635, 266—7, 8
Triarthrus, 654
beckii, 654, 252—17, 18; 276—22
eatoni, 654, 276—23
Triboloceras, 547
digonum, 547, 223—11, 12
Triceratium, montereyi, 301—11
semicirculare, 301—35
Tricoelocrinus, 135
woodmani, 135, 51—13–16
Tricognathus, 241
separata, 243, 93—72
sp. 241, 93—62, 63
symmetrica, 241
Tricrepicephalus, 635
cedarensis, 635, 262—24
texanus, 635, 262—25-28
tripunctatus, 635, 262—11
Trigonarca saffordi, 379
Trigonia, 401
americana, 401, 159—11
emoryi, 401, 159—14
eufaulensis, 401, 159—12, 13
evansana, 401, 159—10
montanaensis, 401, 159—15
quadrangularis, 401, 159—9
vyschetzki, 401, 159—8
Trigoniacea, 399
Trigonirhynchia, 313
sulcata, 313, 120—10–12

Trigonirhynchia, tennesseensis, 313, 120—8, 9
Trigonocallista, 427
deweyi, 427, 170—6, 7
nebrascensis, 427, 170—4, 5
Trigonoceras, 545
Trigonoglossa, 285
nebrascensis, 285, 107—21
Trigonopora, 276
moniliferum, 276, 104—15
vermicularis, 276
Trigonostoma, 514
tenera, 514, 211—35
Trilobita, 599, 601
Lower and Middle Cambrian, 605
Post-Cambrian, 635
Upper Cambrian, 619
Trilobites, alatus, 633
sulzeri, 609
Trilobus, caudatus, 643
punctatus, 645
Trimerella, 285
grandis, 287, 107—33
ohioensis, 287, 108—44-46
Trimerellacea, 283, 285
Trimerus, 643, 654
delphinocephalus, 654, 272—33
vanuxemi, 654, 272—32
Trinucleus, concentricus, 643, 267—2-5
Triplagnostus, 600
lomondensis, 600, 251—21, 22
Triplesia, 307
cuspidata, 307, 117—12-16
lateralis, 303
ortoni, 307, 117—17-21
Triplesiacea, 283, 307
Triplophyllum, 93
spinulosum, 93, 28—16, 17
Tripteroceras, 557
hastatum, 557, 228—21-24
paquettense, 557
planoconvexum, 557, 228—12, 13
Tritaxia, 18
plummerae, 18, 2—7
Tritiaria, 501, 505
mississippiensis, 505, 208—2
Triticites, 23
beedei, 23, 3—7, 8
cullomensis, 23—5, 6
moorei, 23, 3—3, 4
ohioensis, 23, 3—13, 14
osagensis, 23, 3—11, 12
plummeri, 23, 3—1, 2
secalicus, 23, 3—9, 10
tumidus, 23, 4—30-32
ventricosus, 23, 4—34-36
Tritoechia, 298, 105—10
typica, 298, 112—9-14
Trochammina, 29
diagonis, 29, 5—19
Trochelminthes, 228
Trochiliscus, 713
ingricus, 713
octocostatus, 713, 303—1, 2
Trochoceras, 543
baeri, 561
clio, 557
desplainense, 543
eugenium, 561
Trochocyathus, 121
californianus, 121, 45—1, 2
egerius, 121, 45—3, 4
scottianus, 121, 44—14-16
woolmani, 121, 45—5-7
zitteli, 121, 45—8-10
Trocholites, 543
ammonius, 543, 222—1, 2
Trochonema, 451
beloitense, 451, 182—38, 39
fatuum, 451, 182—37
historicum, 451, 182—29, 30
nitidium, 451, 182—35, 36
pulchellum, 451, 182—34
strigillatum, 451, 182—31
tricarinatum, 451, 182—32
umbilicatum, 451, 182—33
Trochonemella, 451
Trochonemopsis, 451
tricarinatum, 451, 182—32
Trochopora, 273
bouei, 273, 103—14
Trochurus, 654
phlyctainoides, 654, 270—1-4
speciosus, 654
Trochus, conchyliophorus, 485
conulus, 480
perspectivus, 489
yvanii, 453
Troosticrinus, 135
reinwardti, 135, 51—2
Troostocrinus, 135
woodmani, 135
Trophocrinus, 149
tumidus, 149, 56—11
Trophosycon, 500
kernianum, 500
ocoyanum, 500, 205—9-11
Tropidiscus, 443
Tropidocaris, 659
alternata, 659, 279—40
bicarinata, 659, 279—33
Tropidocyclus, 443
Tropidodiscus, 443
curvilineatus, 443, 178—10, 11
subacutus, 443, 178—8, 9
Tropidoleptus, 359
carinatus, 359, 140—19, 20
Tropites, 579, 581
subbullatus, 581, 239—1, 2
Trucherognathidae, 237
Trucherognathus, 239
distorta, 239, 93—2, 3
Truncacila, decisa, 375, 146—11
shumardi, 375, 146—10
Truncatulina, soluta, 39
Trupetostroma, 59
warreni, 59, 18—10, 11
Tryblidium, 437
manitoulini, 437, 174—2
reticulatum, 437
striatum, 437, 174—3
Tuberculopleura, 471
Tubicola, 231
Tubipora, catenularia, 113
Tubogyra, 443
Tubucellaria, 275
vicksburgica, 275, 104—3, 4
Tubulibairdia, 685
tubulifera, 685, 288—6, 7
Tubulipora, megaera, 251
Tubulostium, 233
mcglameryae, 234, 92—26-28
Tulotoma, 487
thompsoni, 487, 199—23-26
Tumularia, 105
Tuponia, 51
Turbina, 471
Turbinella, 508
pyruloides, 508
Turbinites, alatus, 467
Turbinolia, 83, 121
dickersoni, 121, 45—14-17
maclurii, 122

Turbinolia, mitrata. 121
pharetra, 121, 45—11-13
pusillanima, 121, 45—18, 19
stokesi, 121
sulcata, 121
Turbo, helicina, 480
plicatus, 481
scalaris, 481
shumardi, 473
tabulatus, 457
terebra, 491
Turbonilla, 481
coalvillensis, 481, 197—16
interrupta, 481, 197—15
nivea, 481, 197—14
plicatula, 481
typica, 481
Turbonopsis, 473
shumardi, 473, 194—1, 2
Turridea, 435
Turrilepas, 695
cancellatus, 695, 293—5
devonicus, 695, 293—4
nitidulus, 695, 293—6
tener, 695, 293—1-3
wrightii, 695
Turrilites, 593
brazoensis, 593, 245—5, 11
costatus, 593
Turritella, 491, 495
aequistriata, 493, 202—7
apicalis, 493, 202—11
atacta, 493, 202—1
bilineata, 459
brevialis, 495
cooperi, 495, 200—19-25
cumberlandia, 493, 202—9
encrinoides, 491, 202—7, 8
exaltata, 493, 202—17
humerosa, 493, 201—18
indenta, 493, 202—2, 3
inezana, 493, 202—18
mortoni, 493, 201—14-16
mortoni postmortoni, 493, 201—17
ocoyana, 495, 202—16
pacheoensis, 493, 202—13, 14
perattenuata, 493, 202—12
plebeia, 493, 202—4-6
plebeia octonaria, 493, 202—6
subannulata, 493, 202—10
tampae, 493, 201—19
tippana, 493
trilira, 493, 201—13
uvasana, 493, 202—15
variabilis, 493, 202—8
vertebroides, 491, 202—9-12
whitei, 491, 201—6
Tuzoia, 655
retifera, 655, 278—15, 16
Tylorthoceras, 539
ohioense, 539, 219—13, 14
Tylostoma, 483
elevatum, 483, 198—34
torrubiae, 483
Tylothyris, 321
mesacostalis, 323, 122—20, 21
missouriensis, 323, 122—11-14
Typhis, 503
acuticosta, 503, 207—11, 12
curvirostratus, 503, 207—10
obesus, 503
Tytthocrinus, 154

U

Uddenites, 567
schucherti, 567 232—3, 4
Uintacrinidae, 207
Uintacrinus, 207
socialis, 207, 79—31
Ulocrinus, 175
blairi, 175
buttsi, 175, 56—27
kansasensis, 175, 56—26
sangamonensis, 175, 56—28
Ulrichia, 667, 669
conradi, 667, 281—38
robusta, 673
Ulrichicrinus, 158
coryphaeus, 158, 59—13
oklahomae, 158, 59—14
Ulrichodina, 240
prima, 240
sp., 240, 93—36, 37
Ulrichospira, 451
notabilis, 451, 182—28
similis, 451
Umbotropis, 453
Uncaspis, 635
micans, 635, 266—28
unca, 635, 266—25-27
Uncinulina, 313
fallaciosa, 313
Uncinuloides, 315
guadalupensis, 315, 120—49-51
Uncinulus, 313
nucleolatus, 313, 119—35-37
saffordi, 313, 119—31-34
ventricosus, 313, 119—38-41
Ungulina, suborbicularia, 373
Unio, 368, 399
danae, 399, 158—13, 14
dockumensis, 399, 158—3
douglassi, 399, 158—5, 6
dowlingi, 399, 158—9
farri, 399, 158—4
felchi, 399, 158—1, 2
hamili, 399, 158—7, 8
holmesianus, 399, 158—17, 18
margaritiferus, 399
priscus priscus, 399, 158—15, 16
senectus, 399, 158—19
shoshonensis, 399, 158—12
subspatulatus, 399, 158—10, 11
Unitrypa, 263
acaulis, 263, 99—38, 39
scalaris, 263, 99—35-37
Uperocrinus, 195
aequibrachiatus, 197, 76—16
longirostris, 197, 76—23
nashvillae, 195, 76—25
pyriformis, 195, 197, 76—24
Uraster, ruthveni, 211
Urasterella, 211
pulchella, 213, 81—6, 7
Urceolabrum, 480
tuberculatum, 480, 197—1
Urnulina, 13
compressa, 13, 1—2
difflugiaeformis, 13
Uromitra, triptum, 509, 210—17
Urosalpinx, 505
cinerea, 505, 207—3, 4
Utharocrinus, 163
pentanodus, 163, 62—13; 64—18
quinquacutus, 163, 62—14; 64—17
Uvigerina, 37
angulosa, 37
cookei, 37, 8—19
cristata, 35
pigmaea, 37

V

Vaginella, 517
chipolana, 519, 213—28–31
depressa, 517
Vaginoceras, 535
oppletum, 535, 218—5, 6
Vaginulina, 32
webbervillensis, 32, 6—16
Valcourea, 297
strophomenoides, 297, 111—21–24
ventrocarinata, 297, 111—25, 26
Vallacerta, 11
hortoni, 11, 14—17
Vallatotheca, 437
Valvata, 487
cristata, 487
scabrida, 487, 199—29–31
subumbilicata, 487, 199—27, 28
Valvatella, 480
Valvulina, 18
bulloides, 29
ocalana, 18, 2—9
triangularis, 18
Valvulineria, 37
californica, 37
casitasensis, 37, 9—3
Vanikoropsis, 483
suciensis, 483, 198—9
tuomeyana, 483, 198—7, 8
Vanuxemella, 619
contracta, 619, 259—25, 26
Vanuxemia, 381
dixonensis, 381, 147—15, 16
hayniana, 381, 147—13, 14, 17
inconstans, 381
Vasocrinus, 154, 52—23
sculptus, 154, 57—3
valens, 154, 57—2
Vauxia, 53
gracilenta, 53, 55, 16—7, 8
Velates, 479
conoideus, 479
perversus, 480, 197—35–37
schmidelianus, 479
Vellamo, 282, 297, 106—14
trentonensis, 297, 106—14; 111—32–35
Velumella, 273
fusiforme, 273, 103—25
levinseni, 273
Veneracea, 425
Venericardia, 419
alticosta, 419, 167—16
planicosta, 419, 167—22–24
planicosta claiboplata, 419, 167—22
planicosta hornii, 419
smithi, 419, 167—15
Venericor, planicosta, 419, 167—22–24
smithi, 419, 167—15
Veniella, 417
conradi, 417, 166—21, 22
humilis, 417, 166—19, 20
Venilia, conradi, 417
Ventilabrella, 33
eggeri, 33, 35, 8—4, 5
Venula, 681
striata, 681, 286—10, 11
Venus, 368, 425, 427
imbricata, 419
islandica, 417
latilirata, 427, 173—7–9
mercenaria, 427, 170—8, 9; 173—10, 11
meretrix, 427
papyracea, 425
pennsylvanica, 423
securis, 427, 170—10; 172—19
sulcata, 401
Venus, tumens, 427
verrucosa, 425
Vermicularia, 491
spirata, 491, 201—4
Vermiporella, 715
Verneuilina, 18
schizea, 18, 2—8
tricarinata, 18
Versispira, 439
Vertumnia, 403
reversa, 403, 160—2
simplex, 403, 160—1
Vetotuba, 459
Vexillum, 509
plicatum, 509
triptum, 509, 210—17
Vinella, 250
repens, 250, 95—4, 5
Virgiana, 307
barrandei, 307, 115—28
decussata, 307, 115—25–27
Virgulina, 35
miocenica, 35, 8—14
squammosa, 35
Virgulinella, miocenica, 35, 8—14
Visitator, 473
Vitulina, pustulosa, 319
Viviparus, 485, 487
conradi, 485, 199—15, 16
couesii, 485, 199—17
fluviorum, 485
raynoldsianus, 487, 199—14
trochiformis, 485, 199—12, 13
Vogdesia, 654
bearsi, 654, 268—4, 5
vigilans, 654, 268—20, 21
Volborthella, 531
tenuis, 531, 217—6-8
Volsella, 413
alabamensis, 413, 164—17
directa, 413, 164—15
multilinigera, 413, 164—16
recta, 413, 164—15
saffordi, 413, 164—18
Voluta, 508, 513
dubia, 508
glabella, 509
musica, 508
nucleus, 508
plicaria, 509
pyrum, 508
reticulata, 514
tornatilis, 515
Volutilithes, 508
conradi, 508, 509
leioderma, 508
limopsis, 508
muricina, 508
navarroensis, 508, 509
Volutocorbis, 508
limopsis, 508, 209—7
petrosus, 508, 209—3–5
rugatus, 508, 209—6
Volutoderma, 508, 509
ambigua, 509, 209—18, 19
averillii, 509, 209—21
dalli, 509, 209—16, 17
protracta, 509, 209—20
texana, 509, 209—22
texturata, 509
Volutomorpha, 508, 509
conradi, 509
mutabilis, 509, 209—23
Volutospina, 508
Volviceramus, umbonatus, 389, 151—13, 14
Vulvulina, 17

Vulvulina, advena, 17, 2—4
capreolus, 17

W

Waagenella, 443
Waagenia, 443
Waagenoceras, 577
guadalupense guadalupense, 577, 237—4, 5
hilli, 577
mojsisovicsi, 577
Waagenoconcha, 351
montpelierensis, 351, 137—35-38
Waagenophyllum, 89
texanum, 89, 25—30
Wachsmuthicrinus, 181, 67—4
spinulosus, 181, 68—8
Walcottella, 655
apicalis, 655, 278—5
Waldheimia, formosa, 361
Wanneria, 619
walcottana, 619, 253—20
Washistater, 226
Washitaster, riovistae, 226 88—8
Wedekindellina, 19, 21
euthysepta, 21, 3—27-29
Welleraspis, 635
jerseyensis, 635, 266—24
Wellerella, 315
delicatula, 315, 120—32-34
immatura, 315, 120—30, 31
osagensis, 315, 120—27-29
tetrahedra, 315
Welleria, 677
obliqua, 677, 284—43, 44
Wellerites, 575
mohri, 575, 236—7, 8
Wellerocystis, 127
kimmswickensis, 127, 47—14, 15
Westonoceras, 561
nelsonensis, 561, 230—2
Weymouthia, 619
nobilis, 619, 252—16
Whiteavesia, 411
cincinnatiensis, 411, 164—3
Whitella, 381
obliquata, 381, 147—18, 19
scofieldi, 381, 147—6, 20
ventricosa, 381, 147—21, 22
Whitfieldella, 331
nitida, 331, 126—47-49
quadrangularis, 331
Whitfieldoceras, 557
mumiaforme, 557, 229—1, 2
Wilbernia, 635
pero, 635, 266—20-22
Wilsonicrinus, 185
discoideus, 185, 72—26
Wimanella, 293, 295
appalachia, 295
rossensis, 295, 110—18-21
simplex, 293, 110—26-28
Worms, 228
Worthenia, 457
speciosa, 457, 185—5-7
tabulata, 457, 185—4
Worthenopora, 271
spinosa, 271, 103—15, 16

X

Xancus, 508
chipolanus, 508, 209—9
Xanthiopyxis, umbonata, 301—14
Xenaspis, 569
marcoui, 569, 233—3-5
skinneri, 569, 233—11, 12
Xenocrinidae, 189
Xenocrinus, 189
baeri, 189, 72—2
pencillus, 189
Xenodiscites, 569
waageni, 569, 233—10
Xenodiscus, 569
plicatus, 569
waageni, 569, 233—13-15
Xenophora, 485
conchyliophora, 485, 199—7-9
laevigata, 485
leprosa,.485, 199—10, 11
Xenopoda, 599, 655
Xenostegium, 654
belemnurum, 655, 267—30, 31
Xestoleberis, 693
truncata, 693, 292—36-40
Xiphosura, 705
Xylobius, 701
sigillariae, 701, 294—18-20
Xylodes, 99

Y

Yezoites, 589
Yoldia, 377
eborea, 379, 146—36
evansi, 377, 146—40, 41
longifrons, 379, 146—38, 39
scitula, 379, 146—42
strigata, 379, 146—37
Yorkia, 287
wanneri, 287, 108—18-20
Yunnania, 451
leavenworthana, 451, 183—7
subsinuata, 451, 183—8
termieri, 451
Yvania, 453

Z

Zacanthoides, 605, 619
romingeri, 619, 257—24, 25
typicalis, 619, 257—20-22
Zanthopsis, 701
vulgaris, 701, 297—23-25
Zaphrentis, 2, 91, 93, 101
calcariformis, 87
cassedayi, 87
cystica, 93
giganteum, 93
glans, 85
phrygia, 91, 27—15-17
prolifica, 91
spatiosa, 91
tenella, 91
terebrata, 93
traversensis, 93
ungula, 91
Zeacrinites, 161, 165, 167
magonoliaeformis, 165, 61—1
sellardsi, 165, 63—17
wortheni, 165, 61—2
Zeacrinitidae, 165, 171, 52—13
Zeacrinus, acanthophorus, 165
elegans, 165
formosus, 171
girtyi, 167
nodosus, 161
robustus, 163
Zemistephanus, 585
richardsoni, 585, 241—15-17
Zittelella, 51
typicalis, 51
varians, 53, 15—8, 9
Zitteloceras, 545, 557
billingsi, 557
clarkeanum, 557, 229—3

Zitteloceras, hallianum, 557
Zoantharia, 101, 115
Rugosa, 83
Zonidiscus, 443
Zonotrichites, 715
Zophocrinidae, 147
Zophocrinus, 147
howardi, 147, 54—20
Zygobeyrichia, 675
apicalis, 675
ventricornis, 675, 283—41
ventripunctata, 675, 283—42–44
Zygobolba, 677
bimuralis, 677, 284—17, 18
decora, 677, 284—15, 16
Zygobolbina, 677
conradi, 677, 284—1, 2
Zygopleura, nodosa, 461
Zygosella, 677
vallata, 677, 284—3, 4
Zygospira, 283, 317
kentuckiensis, 317, 120—54, 55
modesta, 317, 120—72
recurvirostris, 317, 120—56

INDEX OF SPECIES

[When a species name of adjective form is followed by two or more names of differing gender the appropriate endings are added to the specific name. The numbers refer to page and plate-figure.]

A

abenacus, Paradoxides, 615, 254—8
aberti, Scutella, 221, 85—13–15
abichianus, um, Gastrioceras, 573
Goniatites, 573
abnormis, Paraechmina, 665
abruptus, a, um, Anchura, 497, 203—22
Bathyurellus, 637
Cadulus, 523, 214—29
Delocrinus, 173, 62—33; 65—17
Stenotheca, 701, 297—2-4
absolutiformis, Belemnites, 597
abundans, Clathrodrillia, 514
abundum, Stenopoceras, 549, 224—16, 17
abyssina, Gyrodes, 483, 198—16, 17
Margarites, 480, 197—7–9
acadicus, a, um, Acadagnostus, 600, 251—11, 12
Ctenopyge, 623, 263—5–7
Hyolithes, 525, 215—15
Palaeochara, 713
Scenella, 437, 175—1, 2
acamas, Scutellum, 653, 269—17
acanthicus, Durangites, 587
acanthophorus, Hydreionocrinus, 165
Sciadiocrinus, 165, 62—11; 64—1
Zeacrinus, 165
acaulis, Unitrypa, 263, 99—38, 39
acclinis, Taras, 423, 168—29, 30
achates, Achatella, 637, 273—17
Dalmanites, 635
aciculum, Bactrites, 565, 231—1, 2
acinaces, Oenonites, 231, 91—55
acinus, Stegerhynchus, 309, 118—34–37
acme, Fusulina, 23, 3—16, 17
acteoglypha, Mitra, 509, 210—9
aculeatus, a, um, Echinocrinus, 217, 82—7–12
Liostracus, 605
Syringopora, 115, 42—11, 12
acuminatus, a, um, Ceratiocaris, 657, 278—17, 18
Lophospira, 451, 182—23
Loxoplocus, 451, 182—23
Oistodus, 240, 93—24, 25
Paraspirifer, 323, 123—3–5
acus, Leonardophyllum, 89, 26—1–3
acuticosta, Typhis, 503, 207—11, 12
acutilineatus, a, um, Lucina, 423, 168—25
Lucinoma, 423, 168—25
Phacoides, 423, 168—25
acutilirata, Platystrophia, 299, 113—21–24
acutirostra, Pleurotoma, 513
acutirostris, Cyrtina, 359, 140—31–34
acutus, a, um, Brachial, 209, 79—19
Hindeodella, 241, 93—47
Hyolithes, 523
Nuculana, 377, 146—26, 27
Pachydictya, 270, 102—3, 4
Proplina, 437, 174—4–6
Saukia, 633, 260—30
adairensis, Marginifera, 351, 137—20–23
adamsi, Adrianites, 575, 236—11
Lecythiocrinus, 154, 53—20
Ptychoparella, 617, 259—10, 11
adansonii, Cerithium, 497
adherens, Calcivertella, 29, 5—13
adjutor, Bembexia, 457, 184—29
admota, Proboscina, 250, 95—15
adnascens, Liljevallia, 343, 132—41, 42
adscensionis, Pecten, 403
advenus, a, um, Discocyclina, 47, 12—14, 15
Nonion, 33, 7—7
Patellina, 37, 9—8
Planularia, 21, 6—5
Vulvulina, 17, 2—4
adversa, Caprina, 421
adversarius, Conus, 514, 211—8
aedilis, Eridotrypa, 258, 98—21, 22
aegeria, Odontocephalus, 649, 273—4–6
aequa, Bairdia, 683 287—29, 30
aequabilis, Paradelocrinus, 173, 62—3; 65—20
aequalis, Coelochilina, 673, 283—15
Eurychilina, 673
Pachylocrinus, 161, 60—10
Scaphiocrinus, 161
Scaphites, 589
Spirolina, 15
aequibrachiatus, Uperocrinus, 197, 76—16
aequiplicata, Plectoconcha, 365, 143—27–31
Rhynchonella, 365
aequistriata, Turritella, 493, 202—7
aequoreus, Hardouinia, 225, 86—13–15
affinis, Nodosaria, 31, 6—11–13
Raphistomina, 447, 181—3, 4
Taxocrinus, 177
africana, Dosinia, 427
agassizi, Aulocrinus, 171, 61—14
Echinocrinus, 217, 82—1–3
Leptodesma, 385, 149—14
agglutinans, Spirolina, 15
Textularia (var. biformis), 17
aggregatum, Cystiphyllum, 101, 33—18
Cystiphyllum (var. caespitosum), 101
agrigentium, Simoceras, 587
ainsliei, Rostricellula, 309, 118—1-3
alabamaensis, Rhizocrinus, 205, 79—1
alabamensis, Agaronia, 511, 210—13
Aturia, 549, 225—10, 11
Eponides, 39, 9—7
Hantkenina, 41, 11—4
Olivella, 511, 210—13
Polytoechia, 298
Volsella, 413, 164—17
alaskensis, Brooksina, 305, 115—31–33
alatus, Trilobites, 633
Turbinites, 467
alba, Cylichna, 517, 212—21
Rhakistella, 55, 16—14
albaria, Mactra, 431, 171—16
Spisula, 431, 171—16
albequus, Pleurophorus, 415, 165—35, 36
albertensis, Illaenurus, 627, 260—15
albus, Polinices, 483
alcesense, Eutrephoceras, 549, 225—4, 5
aldrichi, Corbula, 431, 172—13, 14
Strombus, 499, 204—1, 2
aldrovandi, Panope, 431
alexanderi, Cytheretta, 688, 291—2–6
Flabellammina, 15
alexandrina, Bairdia, 683, 287—37

alia, Spondylospira, 359, 140—48–51
alleganius, Cooperidiscus, 131, 49—16
Lepidodiscus, 131
alleghaniensis, Arthrophycus, 719, 303—26, 27
Endelocrinus, 173, 65—5
allisoni, Galateacrinus, 165, 64—13
allophylus, Platycrinites, 203, 77—16
allumettense, Ormoceras, 555, 227—13, 14
alpena, Dactylocrinus, 181, 69—14
alpenensis, Cyrtina, 359, 140—35, 36
alpheus, Tremanotus, 443, 178—1, 2
altantoides, Pelagiella, 439, 175—17, 18
alternatus, a, um, Cancellaria, 514, 211—20
Ceramopora, 253
Chirognathus, 237, 93—12
Conchopeltis, 79, 23—1, 2
Diplodella, 240, 93—64, 65
Echinoconchus, 350, 137—10–12
Heliophrentis, 91
Icriodus, 245
Megacystites, 125, 47—2
Rafinesquina, 131
Strophemena, 337
Tropidocaris, 659, 279—40
alticosta, Venericardia, 419, 167—16
alticostata, Octonaria, 682, 286—30, 31
altilis, Ancillaria, 511
altirostris, Eumetria, 361, 141—35–37
altispiralis, Shansiella, 457
altoonensis, Octonaria, 682, 286—26, 27
altudense, Pseudogastrioceras, 575, 236—1, 2
altus, a, um, Cavusgnathus, 245
Cymbophora, 431, 171—19, 20
Cyprimeria, 425, 169—23, 24
Inoceramus, 389
Leperditia, 664, 280—9–12
Myophoria, 401, 159—5
Sismondia, 221
Syringospira, 327, 125—15–17
alvea, Glyptopleura, 681, 285—56, 57
alveata, Amauropsis, 481, 197—30
Architectonica, 489, 200—13, 14
Cassidula, 501
Grammysioidea, 371, 144—21, 22
Lacinia, 501, 205—22
Stellaxis, 489, 200—13, 14
alveolaris, Orthoceratites, 595
alveolata, Columnaria, 99
Favistella, 99, 32—4, 5
amarula, Melania, 489
amata, Dresbachia, 623, 264—22
ambiguus, a, um, Spirifer, 335
Volutoderma, 509, 209—18, 19
amblyoceras, Cymatogonia, 301—13
ambocoelioides, Echinocoelia, 329, 126—27–31
americanus, a, um, Allagecrinus, 147
Alokistocare, 605, 255—16
Amphoracrinus, 195
Aphetoceras, 541
Aviculopinna, 387, 150—10
Belemnitella, 597, 250—13–18
Bollia (var. zygocornis), 667, 281—29–31
Botryocrinus, 155, 57—11
Clidochirus, 183, 54—3
Cystiphyllum, 99, 33—11–13
Daonella, 393, 152—28
Dawsonoceras, 539, 220—10
Dictyoclostus, 350, 136—15–19
Drepanochilus, 497, 203—24
Drepanochilus (var. pusillum), 497
Eouvigerina, 35, 8—10
Harpactocarcinus, 701, 296—5–10
Hybochilocrinus, 147, 56—2
Hyolithes, 525, 215—1–6
Illaenus, 647, 268—16–18
Kochina, 613, 253—14, 15
americanus, Leptodus, 345, 134—30, 31
Lithostrotionella, 89, 26—13, 14
Lyellia, 103, 35—9–11
Maladia, 627, 265—28, 29
Marsupites, 207, 79—26
Micrabacia, 117
Micraster, 226, 90—6–9
Myrtillocrinus, 153, 57—16
Olenopsis, 613
Oligoptycha, 515, 212—7, 8
Pentremitidea, 135, 50—22
Platyclymenia, 565, 231—20
Platycrinites, 203, 77—17
Plesiaster, 226, 90—6–9
Pleuroclymenia, 565, 231—20
Rhynchotreta, 309, 118—23–25
Rostellaria, 497
Sagenocrinites, 179, 54—11
Tancredia, 423, 168—20
Trigonia, 401, 159—11
ammonius, Trocholites, 543, 222—1, 2
amphicylindricus, Cannartiscus, 48, 14—20
amphora, Acrocrinus, 199, 78—15
amplectans, Sansabella, 679, 285—5–7
amplexicaulis, Amplexograptus, 73, 22—8–10
Diplograptus, 73, 22—8–10
amplexus, Planorbis, 519, 213—14, 15
amplus, a, um, Crenipecten, 403, 160—12
Holopea, 469, 192—3, 4
Lingulella, 285
Oenonites, 231, 91—73
Strophonella, 339, 130—25–28
ampulla, Bullus, 517
ampullaria, Natica, 483
amygdalina, Ambonychia, 385, 149—22
analoga, Leptaena, 343, 132—28, 29
anatinus, Conocephalites, 629
Monocheilus, 629, 266—1–3
anax, Clavaspidella, 609, 259—22
anceps, Baculites, 583
Gonioceras, 553, 227—15
anchiops, Anchiopsis, 637, 274—20–22
Calymene, 637
anchoralis, Scaliognathus, 245, 94—37, 38
andersoni, Pecten, 407, 162—8–10
Plagioctenium, 407, 162—8–10
andrewsi, Strophostylus, 475, 194—12
Technocrinus, 200, 74—8
angeiodes, Ostracites, 421
angelica, Athyris, 333, 127—48–51
angelicoides, Athyris, 333, 127—46, 47
angelini, Euomphalus, 465
Glyptagnostus, 600, 251—28
angularis, Bactrognathus, 243, 94—15, 16
Plocezyga, 463, 187—31
Rhaphoneis, 301—6, 7
angulatus, a, um, Cimitaria, 414, 165—19
Cordylodus, 240, 93—71
Eoasianites, 573, 235—20, 21
Hibbardella, 241, 93—73
Lituites, 541
Prorhynchus, 371, 144—30
Spirorbis, 231
angulosa, Reptolunulites, 275
Uvigerina, 37
angustatus, Pteronites, 391
angustifolius, Diplograptus, 73, 22—22
Glyptograptus, 73, 22—22
Phyllograptus, 70, 21—7
Serpulites, 79, 23—3
angustus, Pentremites, 134, 50—16–18
anna, Aulopora, 113, 40—9
Hexagonaria, 95, 30—19, 20
Phyllograptus, 70, 21—8
annectans, Leptograptus, 71, 21—24
annectens, Aulocaulis, 113, 40—12

anneliesae, Anglicornus, 559, 229—15
annosus, Surculites, 514
annulatus, a, um, Clymenia, 565
Cyclendoceras, 535, 218—1, 2
Cyrtoceras, 543, 222—3
Diplopora, 302—3-10
Endoceras, 535
Helicoceras, 593
Spirorbis, 233, 92—8
anosoffi, Spirifer, 321
antelopensis, Hesperonomia, 297
anteradiata, Anatimya, 415, 165—20
Pholadomya, 414
anteros, Bathyuriscus, 615
Poliella, 615, 256—2, 3
anthraosia, Spirorbis, 233, 92—9, 10
anticostiensis, e, Ascoceras, 537
Calapoecia, 109
Schuchertoceras, 537, 218—16
antiguensis, Astreopora, 115, 42—21, 22
antiquatus, a, um, Arca, 381
Bellerophon, 441
Buthotrephis, 717
Cryptophragmus, 63, 19—6-8
Owenella, 441, 176—7, 8
Taras, 423
antiquus, a, um, Arthrolycosa, 709, 300—18
Avicula, 389
Cladochonus, 113
Ebria, 11, 14—16
Mollia, 273
Murex, 505
Stromatopora, 1, 61, 19—1, 2
antiselli, Astrodaspis, 223
antrosa, Cucullaea, 379, 147—9
Idonearca, 379, 147—9
aperta, Calyptraea, 487, 199—38
apertura, Patella, 480
apicalis, Hemipronites, 298
Polytoechia, 298, 112—19-21
Turritella, 493, 202—11
Walcottella, 655, 278—5
Zygobeyrichia, 675
apiculatus, a, Chaetopleura, 527, 216—22-26
Coscinodiscus, 301—34
apion, Kingstonia, 627, 263—28-30
aplanatum, Hadrophyllum, 85, 23—29, 30
appalachia, Wimanella, 295
aqualis, Pelecocrinus, 157, 55—19
aquilaensis, Baculites, 583, 240—1, 2
aranea, Dichograpsus, 69
arata, Atrypa, 305
Cypricardinia, 417, 166—13
Euryzone, 453, 183—38, 39
Pentamerella, 305, 115—19-22
arborescens, Dimerocrinites, 187, 72—5
arboreus, a, Linocrinus, 167, 59—5
Monticuliporella, 255, 97—1, 2
arca, Pulvinulina, 43
Reniera, 56, 16—30
arcaeformis, Sanguinolites, 414
arcanus, Hypselocrinus, 169, 58—17
archiaci, Eridophyllum, 91, 27—11-14
archiaciana, Frondicularia, 32, 6—17
archimedes, Retepora, 264, 100—3
arctica, Nucula, 377
Polystomella, 33
Saxicava, 431, 172—15, 16
arcuaria, Isorthis, 357, 139—51-53
arcuatus, a, um, Chonetes, 347
Cornulites, 233, 92—19, 20
Douvillina, 341, 132—4-7
Drepanodus, 239, 93—42
Eodevonaria, 347, 135—3-5
Geisina, 679, 285—21, 22
Grammysia, 371, 144—26, 27
arcuatus, Gryphaea, 397
Kirkoceras, 533, 217—9
Krausella, 682, 286—51-55
Meristella, 333, 127—20-22
Paltodus, 240, 93—26
Phragmoceras, 561
Pontocypris, 683, 288—1-3
Subbryantoceras, 244, 94—9
arenaria, Serpula, 491
arenosus, Costispirifer, 323, 122—27-31
areolata, Aspidopora, 257
Craniops, 293, 109—35, 36
argentarius, a, Anomia, 409, 163—18, 19
Mucrospirifer, 321, 122—7, 8
argenturbicum, Rhynchotrema, 309, 118—4-6
argutus, a, Dolatocrinus, 201, 74—19
Leptarbacia, 226, 88—15-18
Nyassa, 399, 155—13, 14
Priscoficus, 500, 205—18, 19
arietina, Exogyra, 397, 156—11, 12
ariminensis, Planulina, 43
arion, Maryvillia, 627, 265—31, 32
arkansanus, a, Dalmanitina, 643, 273—18, 19
Graphiodactylus, 681, 285—40-42
Myalina, 393, 153—6
Spirifer, 325, 124—23, 24
arkansasensis, Pronorites, 567, 232—1, 2
arkonensis, Bactrites, 565, 231—3
Spirorbis, 233, 92—5, 6
armadillo, Asaphus, 649
Nileus, 649
armanda, Finkelnburgia, 299, 112—28-30
armatus, a, um, Aorocrinus, 195, 76—10
Arthroclema, 265, 101—2, 3
Bathyurus, 631
Brachymetopus, 639, 275—13-15
Clavagella, 415, 165—29, 30
Lumbriconereites, 229, 91—37
Teguliferina, 351, 137—29, 30
armigera, Euphoberia, 701, 294—9-11, 23, 24
arnoldi, Cactocrinus, 191, 77—4
arrectus, a, Aparchites, 665
Saccelatia, 665, 280—38-40
arthriticus, Gissocrinus, 155
articulatus, Madreporites, 99
articulosus, Cremacrinus, 145, 55—8
artiensis, Chonetella, 347
Goniatites, 569
artus, Didymograptus, 70, 21—16
arundinaceum, Diphyllum, 95
Synaptophyllum, 95, 30—5-7
ashburneri, Cymbophora, 431, 171—26, 27
Mactra, 431
ashermani, Cytherideis, 689, 290—33-36
asininus, Haliotis, 480
aspectans, Asaphus, 641
Coronura, 643, 274-27
asper, Baculites, 583
Hylodecrinus, 161, 60—4
Linocrinus, 167, 64—19
aspera, Dekayia, 258, 98—7
Diodora, 480, 197—13
Favosites, 107, 37—16
asperato-striata, Subretepora, 261, 99—19, 20
asperatus, Eupachycrinus, 175, 64—34
aspersa, Conularia, 79
aspidium, Lindstroemella, 291, 109—27
aspinwallensis, Edmondia, 373, 145—5, 6
astacus, Cancer, 701
asteriaeformis, Onychocrinus, 179, 69—10
asteriscus, Pentacrinus, 207, 79—6
asteromphalus, Coscinodiscus, 301—23
astillerensis, Durangites, 587, 242—8, 9
astoriana, Nuculana, 377, 146—33
astraea, Stephanodiscus, 301—41
astrus, Kallimorphocrinus, 147, 149, 56—3

atacta, Turritella, 493, 202—1
atavoides, Dinorthis, 298, 111—42–44
atlanticus, Archeocyathus, 56, 17—6, 7
atlantoides, Cyrtolithes, 439
atoka, Meristella, 331, 127—17–19
attenarius, Cancer, 701, 297—1
attenuatus, a, um, Acteon, 515, 211—26, 27
Bairdia, 683, 287—27, 28
Cryptonella, 364, 142—22
Dentalium, 523, 214—11
Hamites, 583
Prototreta, 289
Tentaculites, 526, 214—47
Loxonema (var. semicostata), 461
aturi, Nautilus, 549
audaculus, Brachyspirifer, 323, 123—12, 13
audax, Asteractinella, 56, 16—9, 10
aulema, Nanno, 535, 218—3, 4
aurantiacus, Latirus, 507
aurantius, a, um, Cythere, 693
Echinosphaerites, 127, 47—20, 21
Echinus, 127
auriculata, Actinopteria, 391, 152—15
Patella, 487
auriculifera, Cucullaea, 379
auriculus, a, um, Crucibulum, 487
Nautilus, 39
Patella, 487
auris, Planularia, 31
aurora, Chancelloria, 55
Chonetes, 345, 134—10
austinensis, Nerinea, 495, 203—8
Parasmilia, 122, 45—30, 31
austini, Discosorus, 561, 230—16
Kionoceras, 541, 220—13
Lumbriconereites, 229, 91—40
Trachypora, 109, 38—18–20
austinii, Allagecrinus, 149
australis, Entopyla, 301—10
Schizophoria, 357, 139—54–56
avellana, Ampullina, 481, 197—32
Avellana, 515
averillii, Fusus, 508, 509
Volutoderma, 509, 209—21
aviculatus, Pecten, 405, 160—14
aviculoidea, Megambonia, 381, 147—24
aviculoides, Myalina, 393, 153—7
avitas, Menomonia, 627, 265—33, 34
avitus, Eunicites, 229
Paleolimulus, 707, 300—1, 2

B

bacca, Coccocrinus, 201
Lyonicrinus, 201, 77—19
baccula, Pisocrinus, 147, 54—17
baconi, Hyolithes, 525, 215—42–44
baeri, Charactoceras, 563, 230—15
Trochoceras, 561
Xenocrinus, 189, 72—2
baileyi, Bailiella, 607, 253—10–12; 276—21
Conocephalites, 607
Endothyra, 15
bainbridgensis, Aktinocyclina, 47
Discocyclina, 47
Melocrinites, 200, 74—9
bakeri, Alsataspis, 637
baldjikiana, Cocconeis, 301—25
baltica, Acervularia, 101
Philhedra, 291
banioni, Cibolocrinus, 183, 56—29
barabina, Inoceramus, 389, 151—17, 18
barabuensis, Proplina, 437, 174—9, 10
barbarensis, Barbarofusus, 505, 208—1
Fusus, 505
barbata, Arca, 381
barrandei, Aglaspis, 705
barrandei, Asaphus, 637
Basiliella, 637, 267—38
Pentamerus, 307
Virgiana, 307, 115—28
barrandi, Canadocystis, 125, 47—5, 6
Malocystites, 125
Scutellum, 653, 269—16
barretti, Syringostroma, 61, 19—3, 4
barriensis, Bumastus, 639
barrisi, Euryocrinus, 179, 68—22
Meristella, 333, 127—16
Rhodocrinites, 185, 73—7
bartonensis, Cytherideis, 691
basalis, Lumbriconereites, 229, 91—35
basiporosus, Hexastylus, 48, 14—27
bassi, Dictyoclostus, 350, 136—22
bassleri, Allagecrinus, 149, 56—9
Asaphocrinus, 181, 54—9
Calceocrinus, 145, 55—15
Cythereis, 688, 289—28–30
Hollinella, 669, 282—14, 15
bastropensis, Cytherelloidea, 687, 289—5
batesi, Lytoceras, 581, 239—17, 18
bayfieldi, Ormoceras, 555
beachleri, Calliocrinus, 201, 75—18
bearsi, Isotelus, 654
Vogdesia, 654, 268—4, 5
beckeri, Trachyceras, 579
beckii, Rhytistrophia, 341, 131—26–28
Strophodonta, 341
Triarthrus, 654, 252—17, 18; 276—22
becraftensis, Cordania, 641, 274—23, 24
beecheri, Cladochonus, 113, 40—18–21
Emperoceras, 593, 246—12, 13
beedei, Heterocoelia, 56, 17—4, 5
Triticites, 23, 3—7, 8
beggi, Glabrocingulum, 455
belemnurus, um, Megalaspis, 654
Xenostegium, 655, 267—30, 31
belknapi, Oxytropidoceras, 589, 244—3
bella, Cymella, 415, 165—21, 22
Helenia, 525, 214—37
Tornatellaea, 515, 212—15
bellarugosa, Glyptorthis, 297, 111—14, 15
bellastriata, Cypricardella, 417, 166—4, 5
bellatulus, a, um, Elasmonema, 471, 192—24
Finkelnburgia, 298, 112—22–27
Loxonema, 469
bellicincta, Hormotoma, 459, 185—28
bellicosta, Diraphora, 295, 110—38
Eoorthis, 295
bellilineatum, Neoglyphioceras, 571
Owenoceras, 571, 234—11, 12
bellipuncta, Kirkbyella, 671, 282—43, 44
bellistriatus, a, um, Ambonychia, 385, 149—29, 30
Camptonectes, 405, 160—16
Cornulites, 233, 92—18
Nucula, 375, 145—23
Nuculana, 377, 146—30, 31
Pecten, 405, 160—16
Striatopora, 111, 39—7
bellulus, a, um, Atrypa, 319, 121—10–12
Cosmogoniophora, 413, 164—12
Cryptolithus, 643, 267—6, 7
Dolatocrinus, 201, 74—21
Goniophora, 411, 413, 164—12
Promopalaeaster, 211, 81—2–5
Tentaculites, 526, 214—43, 44
bellus, Decadocrinus, 169, 64—25
beloitensis, e, Actinoceras, 551, 226—3
Ecculiomphalus, 467, 189—23–25
Trochonema, 451, 182—38, 39
benedicti, Saccocrinus, 191, 75—17
bennetti, Derbyia, 345, 133—17–19
benthobatus, Delocrinus, 171, 65—29
berryi, Littorina, 489, 200—11, 12

beudanti, Ammonites, 591
beulli, Salpingostoma, 443, 177—14–16
beyrichi, Nucula, 375, 145—25
Propinacoceras, 567
bialata, Solenodella, 244, 94—6
biapiculata, Naviculopsis, 11, 14—9, 10
bicarinata, Tropidocaris, 659, 279—33
bicincta, Murchisonia, 449
bickmoreanus, um, Bickmorites, 543, 222—7–9
Lituites, 543
bicolina, Bollia, 667
bicolor, Araeosoma, 89—36
bicornis, Climacograptus, 71, 73, 21—35
Dicranella, 669, 281—61, 62
Graptolithus, 71
Kerakephalichas, 649, 279—11, 12
Telephus, 654, 267—24–26
bicostatus, Acodus, 239, 93—30, 31
bidens, Goniatites, 567
bidentata, Metalonchodina, 243, 94—20
Prioniodus, 243, 94—20
bidorsata, Bucania, 441
Tetranota, 441, 177—19
bifasciatus, Pseudocrinites, 127
bifidus, Didymograptus, 70, 21—17
Endelocrinus, 173, 65—2
biforatus, Terebratulites, 299
bifurcatus, a, um, Arthropora, 269, 101—29
Diploporaria, 265, 100—22
Geodites, 56, 16—24, 25
Pterotocrinus, 199, 78—17
Spirifer, 325, 124—10–13
bigeneris, Aechmina, 665, 280—60, 61
bigranosa, Orospira, 467, 189—31
bigsbyi, Actinoceras, 551, 226—1, 2
Cyclaster, 131
Edrioaster, 133, 49—24
Huronia, 553, 227—8
Huronia (var. intermedia), 553, 227—4
bilateralis, e, Aulacophyllum, 101, 34—6
Diplodella, 240
bilineatum, a, Spyroceras, 541, 221—3
Turritella, 459
bilix, Cyclonema, 471, 192—30, 31
Pleurotomaria, 471
Sinum, 481, 198—4
billingsi, Arthroclema, 265, 101—1
Billingsastraea, 97
Billingsastraea (var. nevadensis), 97, 32—10
Chilobolbina, 675, 283—45
Cyrtodonta, 381, 146—58, 59
Hungaia, 647
Hyolithes, 525, 215—7–9
Kainella, 649, 274—9
Ottawacrinus, 158, 53—23
Periglyptocrinus, 199, 73—25
Ptychoparella, 617, 259—9
Salterella, 533, 217—1
Skenidioides, 301, 113—1–6
Zitteloceras, 557
bilobatus, um, Bellerophon, 441
Cytheropteron, 691, 292—3–5
Eocytheropteron, 691, 292—3–5
bilobus, a, Anomia, 355
Bilobites, 355, 138—50, 51
bimuralis, Zygobolba, 677, 284—17, 18
binocularis, Conchidium, 305
binoda, Condracypris, 685
bipennis, Arabellites, 231
Ildraites, 231, 91—76
biperforata, Fenestrapora, 263
biplicata, Leptosolen, 429, 171—10, 11
bipyramidalis, Metablastus, 135, 51—7
biserialis, Globivalvulina, 29, 5—15
biseriatus, Echinoconchus, 350, 137—6–9
bispinosus, Delocrinus, 171, 65—8
bispinulatus, a, Cytherella, 685
Ponderodictya, 687, 288—55–58
biauleatus, a, um, Atrypa, 317
Corbula, 431, 172—8, 9
Cyclospira, 317, 120—57–59
Eumorphoceras, 571, 233—16–18
Grammysia, 371, 144—20
Pentagonia, 333, 127—32–36
Pterinea, 369
biturbinatus, Paulocrinus, 183, 185, 72—20
bivertex, Dicranella, 669, 281—65
blainvillii, Strophonema, 341
blairi, Mespilocrinus, 181, 68—12
Parulocrinus, 175, 64—37
Ulocrinus, 175
blakei, Ceratites, 579
Perissolax, 501, 206—5
blumpiedi, Cytheridea, 689, 290—18–22
Haplocytheridea, 689, 290—18–22
blumenbachi, Calymene, 641
boccar, Dolichometopus, 611
Glossopleura, 611, 258—10
bocki, Fusulinella, 21
boesei, Perrinites, 577
Properrinites, 577, 236—26–29
bohemicus, a, um, Ascoceras, 537
Gomphoceras, 559
Monograptus, 77, 22—23
Panenka, 373
boiplex, Bittium, 495, 203—13
bolliaformis, Jonesina, 679, 285—28–31
boltoni, Arctinurus, 637, 271—1, 8, 10, 19
Paradoxides, 637
bonae-vistae, Cuccoceras, 579, 238—4–7
bondi, Nucleocrinus, 135, 51—10–12
boonensis, Actinocrinites, 193, 77—12
bootes, Pagetia, 615, 252—7–9
boothi, Cryphaeus, 647
Greenops, 647, 274—11, 12
borealis, Anisomyon, 519, 212—37–39
Clio, 517
Duncanella, 83, 23—10
boryi, Proboscina, 250
bosquense, Cerithium, 497, 203—29
bosquetiana, Bairdia, 683
botelloides, Allonema, 250
bottae, Pleurotoma, 513
bouchardi, Pachyphyllum, 97
bouei, Trochopora, 273, 103—14
bovidens, Dielasma, 364, 143—6–8
bowdeni, Donaldiella, 449, 182—20–22
Loxoplocus, 449, 182—20–22
bowersi, Clypeaster, 221, 84—17, 18
bowmani, Endothyra, 15, 17
Popanoceras, 577, 236—24, 25
bownockeri, Paraspirifer, 323
boydi, Actinopteria, 391, 152—19, 20
brachiatus, Paradelocrinus, 173, 62—34; 65—25
brachycephalus, Isotelus, 647, 268—19
bradfieldi, Sansabella, 679, 285—8–13
bradleyi, Catillocrinus, 149
Colpocaris, 657, 279—16
Eucatillocrinus, 149, 55—3
brainerdi, Orthoceras, 535
Proterocameroceras, 535, 218—11–14
branneri, Cassiope, 491, 201—5
Gastrioceras, 573, 235—6–8
bransoni, Aclistochara, 713
Loxodus, 241, 93—45, 46
brazoensis, e, Phymatopleura, 455, 183—35, 36
Pseudoparalegoceras, 573, 235—5
Turrilites, 593, 245—5, 11
brevialis, Turritella, 495
brevicauda, Ptychoparella, 617
brevifrons, Nemodon, 379, 146—50, 51
Ptychopleura, 631

brevifrons, Ptychopleurites, 631, 266—9, 10
brevilineata, Bucanella, 441, 176—17
breviloba, Lisania, 631
Pseudolisania, 631, 266—11–15
brevis, Acodus, 239, 93—32, 33
Agaricocrinus, 195, 76—15
brevispinus, Bathyurellus, 639, 267—32, 33
breweri, Beudanticeras, 591, 245—1, 2
brewerianus, Astrodaspis, 223, 85—6, 7
Nanonavis, 379, 146—47
Parallelodon, 379, 146—47
briareus, Pentacrinus, 207
bridgei, Plectotrophia, 301, 114—1–6
brightseatensis, Eucythere, 689, 291—15
bristoli, Glyptopleura, 681, 285—47
brittanica, Leperditia, 664
brockensis, Anatomites, 581, 239—9–11
Juvavites, 581, 239—9–11
bröggeri, Callavia, 609, 253—17
Holmia, 609
Olenellus, 609
brongniarti, Halymenites, 717
bronni, Phacops, 653
brownstownensis, Eucythere, 689, 291—14
brownwoodensis, Ancistrum, 227, 90—22, 23
brunsvicensis, Belemnites, 597
buccinea, Ringicula, 515
bucinum, Nautilus, 555
Nephriticeras, 555, 228—6, 7
bucklandi, Ecculiomphalus, 467
buehleri, Plethopeltis, 631, 260—4, 5
bufo, Griffithides, 647, 275—9
Spatangus, 225
bulbaceous, Dolatocrinus, 201, 74—18
bulbiformis, Amauropsis, 481, 197—33, 34
bulbosus, a, um, Arachnocrinus, 153, 57—10, 21
Cyathocrinus, 153
Glyptopleurina, 681, 286—9
Tancredia, 423, 168—21
bulbus, Proagnostus, 601, 251—3, 4
bulimiformis, Bulimella, 479
Bulimorpha, 479, 196—5, 6
bullardi, Parasmilia, 122, 45—32
bullatus, a, um, Agaricocrinus, 195, 76—14
Avellana, 515, 212—1, 2
Marginulina, 31, 6—6
Marsipograptus, 67
bulletta, Dorothia, 18, 2—14
Gaudryina, 18
bulloides, Globigerina, 41
Valvulina, 29
burdigalensis, Polymorphina, 32
burgeneri, Bollia, 667, 281—32
burgundiae, Confusastrea, 119
burlingi, Acrothele, 289
Conodiscus, 289, 108—25–28
burlingtonensis, Dictyoclostus, 350, 136—1–3
Forbesiocrinus, 179, 68—20
Metichthyocrinus, 183, 68—6
Platycrinites, 203, 78—24
burnsi, Cytheretta, 688, 291—9–13
bursaeformis, Cercidocrinus, 159, 59—10
Poteriocrinus, 159
burtini, Nautilus, 549
Stringocephalus, 364, 143—4, 5
buttsi, Crepicephalus, 623, 262—13–15
Elrathiella, 611, 255—1
Menomonia, 627, 265—35
Solenopleurella, 617, 255—22
Ulocrinus, 175, 56—27
byramensis, Angulogerina, 37, 8—21
Cytherura, 689, 291—19
Rotalia, 39, 9—9
byronoides, Graptolithus, 69

C

cadens, Desmograptus, 67, 20—21
caducea, Sceptroneis, 301—28
caduloide, Dentalium, 523, 214—14, 15
Laevidentalium, 523, 214—14, 15
caespitosum, Cyathophyllum, 95
Diplophyllum, 99, 32—11, 12
calcaratus, Diplograptus, 73, 21—1
Gilbertsocrinus, 185
Orthograptus, 73, 21—1
calcareus, Hemigordius, 29, 5—10
calcariformis, e, Hapsiphyllum, 87, 24—25–27
Zaphrentis, 87
calceolum, Homalophyllum, 93, 28—23, 24
calcifera, Ribeiria, 659, 297—17–19
Ribeirina, 659, 297—17–19
calhounensis, Dielasmella, 364, 142—14–16
calhouni, Oxoplecia, 307
calicularis, Corynoides, 70, 21—29
caliculum, Enterolasma, 85, 24—11–13
californianus, Trochocyathus, 121, 45—1, 2
californicus, a, um, Auliscus, 301—5
Chiton, 527
Cidaris, 219, 83—5–7
Conus, 514, 211—5
Discotrochus, 117, 43—4–6
Epiaster, 225, 87—4–6
Nuttallina, 527, 216—1–5
Pentacrinus, 207, 79—10
Plectofrondicularia, 35, 8—8, 9
Silicosigmoilina, 27, 5—2, 3
Stictodiscus, 301—24
Trachyceras, 579
Valvulineria, 37
callicephalus, a, Calliops, 639, 273—20–23
Phacops, 639
callicera, Odontopleura, 651, 271—16
calligona, Crassispira, 513, 210—30
callosa, Pleurotomaria, 453
caloosaensis, Fusus, 507
Heilprinia, 507, 208—15
calvertensis, Spirorbis, 233, 92—11
calvini, Batocrinus, 195
Hemiaster, 226, 89—7, 8
Pugnoides, 315, 120—13–17
calyculus, Balanophyllia, 122
Perimestocrinus, 161, 64—2
calymenoides, Conocephalites, 627
Menomonia, 627, 265—36
cameratus, a, um, Leptostrophia, 341
Lumbriconereites, 229, 91—39
Neospirifer, 325, 125—5, 6
Sulcatostrophia, 341, 131—20, 21
campbelli, Barroisella, 285, 107—29–32
Syntrophia, 301
Syntrophina, 301, 114—20–23
camura, Trematospira, 361, 141—19, 20
canadensis, e, Alecto, 251
Amphion, 651
Anomalocaris, 655, 277—6
Aparchites, 664, 280—17–19
Ascoceras, 535
Billingsites, 537, 218—18
Calapoecia (var. anticostiensis), 109, 38—11–15; 38—10
Callocystites, 128, 48—3
Chiton, 526
Favosites, 107, 37—9, 10
Gastroplites, 589, 244—7, 8
Hederella, 251
Hoplites, 589
Housia, 625, 265—7, 8
Linuparus, 699, 295—1
Loricula, 695, 293—7, 8
Megalomus, 381, 147—10–12
Neobulimina, 35, 8—16
Pliomerops, 651, 272—23–25

canadensis, Priscochiton, 526, 216—6–8
Protarabellites, 231, 91—67, 68
Remopleurides, 653, 267—17–19
canaliculatus, a, um, Acteocina, 515, 212—14
Ammonites, 583
Bulimella, 477
Calliostoma, 480, 197—3
Cylicocrinus, 193, 75—16
Girtyspira, 477, 195—15
Murex, 503
Orthodesma, 369, 144—12, 13
Sycotypus, 503
canalifera, Eotomaria, 455, 184—13, 14
canalis, Asaphus, 647
Facetal, 209, 79—23
Isoteloides, 647, 268—9, 10
Orthis, 351
Strombus, 497
canariensis, Nonionina, 15
cancellaria, Morea, 505, 208—6, 7
cancellatus, a, um, Aviculopecten, 401, 159—17
Desmograptus, 67, 20—14
Dictyograptus, 67
Exogyra, 399, 156—15; 157—4
Gigantoceras, 555, 228—4
Kionoceras, 539, 220—9
Nassa, 501
Nucula, 375, 145—34
Pectinucula, 375, 145—34
Sinuites, 441, 176—24, 25
Turrilepas, 695, 293—5
candida, Pholadomya, 414
canna, Dentalium, 523, 214—31
Plagioglypta, 523, 214—31
canyonensis, Kirkbya, 671, 282—22–25
capax, Bathyurus, 629
Cucullaea, 379
Platycolpus, 629, 260—24, 25
Rhynchotrema, 309, 118—7–10
capella, Asaphiscus, 611
Glyphaspis, 611, 259—14–16
capertoni, Baylea, 453, 184—10–12
capillaria, Bembexia, 457, 184—30
capitalis, Asterocrinus, 199
Pterotocrinus, 199, 78—16
capitanensis, Polydiexodina, 27, 4—1, 2
capreolus, Vulvulina, 17
capsa, Schizodiscus, 660, 279—7–9
capsella, Rhonocaris, 659, 279—35
capuliformis, Ceratopea, 447, 181—11–13
caractaci, Calymene, 645
carbonarius, a, um, Amphicrinus, 179, 79—32
Ceratites, 569
Chiton, 527, 216—27–34
Cypricardinia, 417, 166—7
Eoscorpius, 709, 300—10–12
Fistulipora, 255, 96—22, 23
Geodites, 56, 16—20, 22
Naiadites, 399, 155—18
Rhipidomella, 355, 139—24–26
Shansiella, 457, 185—8
Tabulipora, 259, 98—8, 9
Thamnopora, 109, 38—8, 9
carboniferus, a, um, Acanthopecten, 403, 159—26, 27
Jonesina, 681, 285—32–34
Leiorhynchus, 313, 119—14–16
Pecten, 403
cardiiformis, Megambonia, 381
caribaearum, Cassidulus, 223
caricus, a, um, Busycon, 501
Fulgur, 501
Murex, 501
carinatus, a, um, Alectryonia, 395, 153—21
Amphissites, 671, 282—28–30
Asterigerina, 39
Beecherella, 682, 286—56
carinatus, Carinaropsis, 445, 180—1, 2
Gennaeocrinus, 191, 75—23
Helix, 457
Langulina, 32
Mitrella (var. gausapata), 500, 205—24
Orthis, 353
Ostrea, 395, 153—21
Penniretepora, 265, 100—26
Requienia, 421
Spirifer, 323
Strophomena, 359
Tropidoleptus, 359, 140—19, 20
carinifera, Bucanopsis, 443, 178—24, 25
carleyana, Naticopsis, 475, 194—15, 16
carleyi, Orthis, 298
Retrorsirostra, 298, 111—49–51
carlottense, Cymatoceras, 549, 224—11
carolinensis, Cucullaea, 379, 147—4, 5
Etea, 417, 166—23, 24
Idonearca, 379, 147—4, 5
Lithophaga, 413, 164—25–27
caroliniana, Mellita, 223, 86—4–6
carpenteri, Allocatillocrinus, 149, 55—4
Catillocrinus, 149
carseyae, Buliminella, 35, 8—13
carterense, Tetradium, 105
carteri, Choia, 51, 15—17
caryophyllata, Montlivaltia, 117
casitasensis, Valvulineria, 37, 9—3
cassedayi, Zaphrentis, 87
cassinense, Cyclostomiceras, 533, 217—21–23
Gomphoceras, 533
castaneum, Leiorhynchus, 313, 119—10–13
castellana, Stricklandia, 307, 117—5, 6
castelnaui, Lithostrotionella, 89, 26—9–12
castensis, Spiroplectammina, 17, 2—1
casteri, Brevicoceras, 559, 230—1
Tiarasmilia, 121, 45—22, 23
catactus, Elibatocrinus, 159, 57—25
catawbensis, Paurorthis, 355, 138—46–48
catenularia, Halysites, 113, 41—4–10
Tubipora, 113
catenulatus, Halysites, 113
catilloides, Amphiscapha, 465, 188—23–25
Straparolus, 465, 188—23–25
catillus, Laudonocrinus, 165, 64—9
catskillensis, Amnigenia, 399, 155—17
Cypricardites, 399
caudagalli, Fucoides, 719
Taonurus, 719, 303—23, 24
caudatus, Priscoficus, 500, 205—12
Trilobus, 643
caurinus, Pecten, 405
cavanaughi, Rhodocrinites, 185, 73—10
cavatiforme, Metacoceras, 547, 224—12, 13
cedarensis, Tricrepicephalus, 635, 262—24
celebra, Calymene, 641, 272—6, 7
cellarioides, Entalophora, 251
cellulosus, a, um, Antiguastrea, 119, 44—1, 2
Astraea, 119
Clathrodictyon, 61, 18—19, 20
Tetradium, 101, 34—9–11
celsa, Bonnemaia, 677, 284—11, 12
celsalobata, Monoceratina, 693, 292—22–25
cenomana, Caryophyllia, 121
Crisisina, 251
Placopsilina, 31
Siderolina, 41
centralis, Anisomyon, 519
Calyptraea, 487, 199—32–34
Madrepora, 121
centrifuga, Serpularia, 465
centronotus, Amphissites, 671, 282—32–35
cerathophthalma, Phacops, 643
cereoides, Cellaria, 275
cerithidioide, Bittium, 497

cerithidioides, Alabina, 497, 203—17
cestriensis, Bairdia, 683, 287—24-26
Diaphragmus, 349, 135—42-45
Fenestrellina, 263, 99—24
cestrotus, Ctenopterus, 709, 299—7
Stylonurus, 709, 299—7
ceticephalus, Arion, 605
chadwicki, Euryizoceras, 559, 229—8, 9
chambersi, Beyrichia, 667
Ceratopsis, 667, 281—48-50
chapmani, Hemicystites, 131, 49-15
Lebetodiscus, 131, 49—15
charlottensis, Polymorphina, 32, 7—5
charltoni, Holectypus, 221
chelodon, Eucytherura, 691, 291—25, 26
chemungensis, Cornellites, 383, 148—19, 20
Inoceramus, 387
Mytilarca, 387, 149—32, 33
Parallelodon, 379, 146—46
Schizodus, 401, 159—2
chenoderma, Astacus, 701, 296—11-13
chesterensis, Kaskia, 649, 275—29-33
chiajii, Amphiura, 213
chickasawhayensis, Eucythere, 689, 291—18
chiesense, Trachyceras, 579
childreni, Coronia, 513, 210—26, 27
Pleurotoma, 513
chinensis, Patella, 487
chipolanus, a, um, Strombus, 499, 204—3, 4
Vaginella, 519, 213—28-31
Xancus, 508, 209—9
chippewaensis, Lonchocephalus, 627, 265—30
choctavensis, Chlamys, 407, 161—17, 18
Pecten, 407, 161—17, 18
choristites, Enteletes, 357
christneri, Frondicularia, 32
Kyphopyxa, 32, 6—18
christyi, Actinocrinus, 197
Cyphaspis, 643, 276—11-13
Eutrochocrinus, 197, 75—8; 76—21
chromatica, Obolella, 287, 108—8-11
chrysalis, Cheirocrinus, 145
Eucheirocrinus, 145, 55—6
Goniobasis, 489, 200—4
cicatricosa, Ctenoloculina, 667, 281—36, 37
Tetradella, 667
cidaris, Echinus, 219
ciliatus, a, um, Beyrichia, 669
Ctenobolbina, 669, 281—63, 64
Glossograptus, 75, 22—14
cincinnatiensis, Agelacrinus, 129
Beyrichia, 665
Isorophus, 131, 49—8
Milleratia, 665, 281—10-13
Modiolopsis, 411
Whiteavesia, 411, 164—3
cincta, Denisonia, 679
cinctosum, Mitoclema, 251
cinctuta, Fenestella, 264
cinereus, a, Fusus, 505
Urosalpinx, 505, 207—3, 4
cingulatus, a, um, Amplexopora, 258, 97—20-23
Cornulites, 233, 92—13
Kutorgina, 293, 110—1-3
Obolella, 293
circularis, e, Dolorthoceras, 553
Pecten, 405, 407, 157—5, 6
Plagioctenium, 407, 157—5, 6
cirrata, Denisonia, 679, 285—23
cirrifer, Gnorimocrinus, 177, 54—12
Hapalocrinus, 203, 77—21
ciscoensis, Geinitzina, 18, 2—6
Placopsilina, 31, 6—1
citriformis, Bairdia, 683, 287—18-20
claibornensis, Lepidocyclina, 45, 13—14, 15
Loxoconcha, 691, 291—27, 28
claibornensis, Siphoninella, 39, 10—4
clappi, Chonostegites, 113, 115, 41—18, 19
clarkeanum, Zitteloceras, 557, 229—3
clarkei, Thylacocrinus, 185, 72—27
clarkensis, Metichthyocrinus, 183, 68—9
clarkesvillensis, e, Michelinoceras, 537, 219—10, 11
Sowerbyella, 335, 128—39, 40
clarki, Drepanellina, 677, 284—41, 42
Pseudocrinites, 128, 47—33-35
Sagenocrinites, 179, 54—10
clarocarinata, Kirkbya, 671, 282—21
clarus, Cheirocrinus, 145
Deltacrinus, 145, 57—8
clathratum, Actinostroma, 59
clathrodon, Mactra, 431, 171—17, 18
clausa, Meekopora, 255, 96—30-32
Natica, 485, 199—1
Tectonatica, 485, 199—1
clavatula, Proboscina, 250, 95—13
claviformis, Idiognathodus, 246
claviger, Hemiaulus, 301—1
clavigera, Melosira, 301—12
clavus, Lobobactrites, 565, 231—11
claypolii, Rensselaeria, 364
Subrensselandia, 364, 142—8, 9
claytonensis, Scobinella, 513, 210—33, 34
cleon, Aviculopecten, 401, 159—16
clermontensis, Tetralichas, 654, 270—6
clintonensis, Eunicites, 229, 91-24
Monograptus, 75, 22—20, 21
Scolithus, 234, 92—33
clio, Haplocrinites, 147, 56—14
Trochoceras, 557
clorensis, Bythocypris, 683, 287—44, 45
clypeiformis, Athlocrinus, 163, 63—12
clytia, Pagetia, 615, 252—13-15
clytie, Heterorthis, 355, 139—27-29
Orthis, 355
coalescens, Leptochirognathus, 237, 93—1
Oenonites, 231, 91—54
Pleurocora, 119, 44—12
coalingensis, Nodosarella, 37, 8—23
coalvillensis, Turbonilla, 481, 197—16
cobourgensis, Lingula, 285
codyensis, Baculites, 583, 240—10, 11
Baculites (var. obesus), 583
coelatus, a, Marsupiocrinites, 201
Scobinella, 513, 210—32
coeymanensis, Gypidula, 305, 115—1-3
cognata, Architectonica, 491, 200—15
Stellaxis, 491, 200—15
colbii, Remopleurides, 653
collectus, Solenochilus, 549, 224—14, 15
colleni, Acrothele, 289
colletti, Taxocrinus, 177, 69—5
colligatum, Eridophyllum, 91, 27—6-10
coloradoensis, Acanthopecten, 403, 159—25
Billingsella, 293
Pyropsis, 501, 206—8, 9
columbella, Exogyra, 397, 156—1-3
columbica, Heritschia, 87, 25—29
columbina, Rhinocaris, 659
columnare, Stylodictyon, 61, 18—23, 24
comancheanus, Inoceramus, 389, 151—11
comatus, Nautilus, 31
comis, Arabellites, 229, 91—6
Gypidula, 305, 115—10, 11
commaticus, Eratocrinus, 165, 61—3
communis, Actinopteria, 391, 152—16
Archimedes, 264, 100—5
Cythereis, 688, 289—35-39
Dentalina, 31, 6—7
Drilluta, 513, 210—35, 36
Forbesiocrinus, 179, 68—19
Grammysia, 371, 144—23
Guttulina, 32

communis, Hyolithes, 525, 215—34-41
Mitrella, 500, 205—25
Polygnathus, 245, 94—29-31
Polymorphina, 32
compactilis, Adinocrinus, 161, 60—23
compactus, a, um, Dinotocrinus, 161, 61—12
Halysites, 113, 41—11-14
Lecanospira, 467, 189—32-34
Linocrinus, 167, 64—23
Murchisonia, 459
Ophileta, 467
Parulocrinus, 175, 64—36
Schwagerina, 27
Solenopora, 717, 302—31; 303—30-32
Stegocoelia, 459
complanatus, a, um, Chonostrophia, 347, 135—9, 10
Cypricardella, 415, 166—1
Dicellograptus, 71, 21—30
Frondicularia, 32
Lenticulites, 33
Ophileta, 447, 181—30-32
complexa, Cythere, 689
Plummerinella, 29, 5—14
complexicosta, Chlamys, 405, 161—5
Pecten, 405, 161—5
complicatus, Cyrtoniodus, 240, 93—68
compressus, a, um, Baculites, 583, 240—3-5
Belodus, 240, 93—56
Clavulina, 18, 2—11
Cotteroceras, 535, 218—15
Eunella, 364
Millepora, 275
Petalotrypa, 258, 97—26, 27
Phragmolites, 443, 178—5
Urnulina, 13, 1—2
comtus, Cordylocrinus, 203
conanti, Planorbis, 519, 213—7, 8
concavus, a, um, Balanus, 695, 293—14-31
Coelospira, 319, 121—19-21
Dactylocrinus, 181, 68—1
Euryocrinus, 179
Leptaena, 343
Leptaenisca, 343, 132—34, 35
Leptocoelia, 319
Megastrophia, 339, 130—25; 131—1-4
Megistocrinus, 191, 75—12
Plectofrondicularia, 35
Protarabellites, 231, 91—66
Strophodonta, 339
concentricus, a, um, Lichenalia, 255, 271, 96—21; 103—4
Lingula, 291
Modiolopsis, 409, 163—29, 30
Modiomorpha, 409, 164—2
Polygnathus, 245, 94—47
Polylophodonta, 245, 94—47
Porodiscus, 48, 14—23
Pterinea, 409
Schizobolus, 291, 109—19-21
Stromatopora, 59, 61
Terebratula, 333
Trinucleus, 643, 267—2-5
conchyliophorus, a, um, Trochus, 485
Xenophora, 485, 199—7-9
concinnus, a, um, Acteon, 515
Calymene, 651
Cinulia, 515
Nucleospira, 331, 127—5-7
Oligoptycha, 515
condoni, Prionothyris, 364, 142—20, 21
condor, Neospirifer, 327, 125—1, 2
confertus, a, um, Aulopora, 111, 40—5
Haimesiastraea, 122, 46—1-3
Lambeoceras, 555, 227—12
Monticularia, 63
Penniretepora, 265, 100—27
Schistocrinus, 165, 64—32
confluens, Thlipsura, 682, 286—14-16
congesta, Athyris, 331
Hyattidina, 331, 127—1-4
Ostrea, 395, 154—1, 2
congregata, Atrypa, 311
Camarotoechia, 311, 118—50-53
conicus, a, um, Agassizocrinus, 175, 177, 61—7
Alloprosallocrinus, 195, 75—4
Bathyurus, 647
Clathrospira, 455, 184—31-33
Hybocrinus, 151, 53—22
Hystricurus, 647, 267—27
Lunulites, 273
Microdoma, 471, 192—9-11
Orophocrinus, 134, 50—6, 7
Orthonema, 475, 195—2
Orthonychia, 473, 193—17
Platyceras, 473, 193—17
Porocrinus, 153, 53—13
Pseudoglandulina, 32, 6—8
Synbathocrinus, 151
Tetrataxis, 31
conifollis, Cystiphyllum, 101, 33—8-10
connata, Coosia, 623, 264—23, 24
conoideus, a, um, Discosorus, 561, 230—3, 4
Odostomia, 481, 197—21
Omphalotrochus, 467, 191—5-7
Pentremites, 134, 50—11-13
Velates, 479
conradi, Ammonites, 589
Dinobolus, 285, 107—22-24
Discoscaphites, 589, 243—17-19
Gyrodes, 483, 198—18, 19
Nemodon, 379
Obolus, 285
Pecten, 405, 161—9, 10
Ulrichia, 667, 281—38
Veniella, 417, 166—21, 22
Viviparus, 485, 199—15, 16
Volutilithes, 508, 509
Volutomorpha, 509
Zygobolbina, 677, 284—1, 2
conradiana, Cancellaria, 514, 211—22
Gyrodes, 483
conradinus, Mytilus, 413, 164—19
consimilis, Cypricardinia, 417, 166—8, 9
consobrinus, Mucrospirifer, 321, 122—9, 10
consortale, Bradfordoceras, 553, 226—11
constellata, Ceripora, 259
Constellaria, 259, 98—16-20
Stromatopora, 61, 19—5
constrictus, a, um, Colpomya, 411, 164—4, 5
Dystactocrinus, 149, 52—11
Heterocrinus, 149
Nuculites, 377
Oncoceras, 557, 228—10, 11
Palaeoneilo, 377, 146—20, 21
Primitiella, 665, 281—1-4
contortus, Eunicites, 229, 91—25
contractus, a, um, Beyrichia, 675, 283—27, 28
Camarotoechia, 311, 118—54-56
Sphenotus, 414, 165—4
Vanuxemella, 619, 259—25, 26
contrarium, a, Busycon, 501, 206-19
Rotalina, 39
conulus, Trochus, 480
convexus, a, um, Arionellus, 621
Camaraspis, 621, 260—12-14
Cytheropteron, 691
Deissella, 609, 255—15
Gryphaea, 397, 155—15, 16
Moorites, 673, 283—13, 14
Plethometopus, 631, 260—6, 7
Pleurodictyum, 111, 40—1-3
Ptychoparia, 609
Syntrophina, 301

convolutus, a, Kootenia, 613, 257—1–4
Myelodactylus, 143, 54—26
cookei, Athecocyclina, 47, 12—12, 13
Pseudophragmina, 47, 12—12, 13
Uvigerina, 37, 8—19
cooperi, Antalis, 523, 214—22, 23
Cardium, 425, 169—17
Dentalium, 523, 214—22, 23
Lumbriconereites, 229, 91—41, 42
Oenerorthis, 293, 110—22–25
Parenteletes, 357, 140—21–23
Turritella, 495, 200—19–25
coosensis, e, Cardium, 425, 169—12, 13
Foscutella, 223, 85—3
Kochaspis, 611, 257—12, 13
Scutella, 223
copei, Myalina, 393, 153—10
Physa, 519, 213—1, 2
cor, Isocardia, 425
cora, Athyris, 333, 127—38
Crotalocrinites, 153, 54—30
Productus, 351
coralloides, Amplexus, 93
coranguinum, Spatangus, 226
corbis, Cardium, 425
Ichthyocrinus, 183, 68—11
corbuliformis, Nucula, 375, 145—24
corbuloidea, Thracia, 415
cordatus, a, Ammonites, 585
Metacypris, 693
cordiformis, e, Bucanella, 441, 176—9–14
Cardioceras, 585, 242—1, 2
cordillerae, Conocephalites, 611
Elrathina, 611, 255—4
cordillerana, Halobia, 393, 153—3
coreyi, Histocrinus, 169, 60—22
Lepidesthes, 219, 82—16
Poteriocrinus, 169
coriacea, Acrothele, 289, 108—15–17
Flustra, 273, 103—26
Micropora, 273, 103—26
cornea, Helix, 519
Tellina, 419
corniculum, a, Caryophyllia, 91
Streptelasma, 85, 24—1–3
corniger, Prioniodus, 241, 93—54
cornigerus, a, um, Dichocrinus, 199
Lithodesmium, 301—15
Talarocrinus, 199, 78—12
cornucopia, Stenotheca, 701
cornucopiae, Caninia, 91
cornu-oryx, Orthoceras, 533
Orygoceras, 533, 217—14–16
cornutaformis, e, Metoptoma, 437
Proplina, 437, 174—11
cornutus, a, um, Cythereis (var. americana), 688, 289—40–43
Lasanocrinus, 163, 62—6; 63—15
Platyceras, 473, 193—1, 2
Platyostoma, 473, 193—1, 2
Pterygocythereis (var. americana), 688, 289—40–43
corona, Hemizyga, 463
Plocezyga, 463, 187—19
coronatus, a, um, Chonetes, 345, 347, 134—12–15
Conocephalus, 609
Curtognathus, 239, 93—15
Eunicites, 229, 91—26
Nautilus, 547
Temnocheilus, 547
coronula, Fungia, 117
corpulenta, Resserella, 353, 138—8, 9
Thlipsura, 681
corroboratus, Merocrinus, 155, 53—17
corrugatus, a, um, Amplexus, 93, 29—16, 18
Cornulites, 233, 92—15, 16
Cyrtotheca, 69
corrugatus, Facetal, 209, 79—16
Gryphaea, 397, 155—10, 11
Gryphaea (var. belviderensis), 397
Gryphaea (var. hilli), 397
Gryphaea (var. tucumcarii), 397
Loxopteria, 385, 149—17
Patellina, 37
Perimneste, 713, 303—10–12
corticata, Oliva, 511
coryelli, Glyptopleura, 681, 285—52
coryphaeus, Ulrichicrinus, 158, 59—13
coscinodiscus, Craspedodiscus, 301—32
cossmani, Bittium, 495, 203—16
cossus, Poulsenia, 615, 259—4, 5
costalis, Bucania, 441, 177—5–8
costatus, a, um, Allorisma, 414, 165—2
Ancistrorhyncha, 307, 117—30–33
Arca, 415
Calliostoma, 480
Cardium, 423
Cribroconcha, 685
Crucibulum, 487, 200—31, 32
Eugeniacrinites, 201
Exogyra, 231, 233, 397, 399, 156—13, 14; 157—2, 3
Lasiograptus, 75
Montastrea, 119, 44—4
Pereichocrinites, 189
Scutellum, 653
Turrilites, 593
costellata, Archaeorthis, 295
couesii, Viviparus, 485, 199—17
cowichanensis, Confusastrea, 119, 43—21
coxanus, Cydrocrinus, 157, 58—18
Endolobus, 547, 223—15, 16
Poteriocrinus, 157
craginiana, Axosmilia, 122, 46—9
crassibasale, Dictyonema, 65, 20—2
crassicauda, Entomostracites, 647
crassidiscus, Hydreionocrinus, 163
Plaxocrinus, 163, 62—7; 63—7
crassimarginatus, a, um, Dikelocephalus, 633
Proetus, 651, 274—18, 19
Schmidtella, 664, 280—35–37
Tellerina, 633, 261—5, 6
crassinoda, Depranella, 667, 283—1–3
crassiplicata, Corbula, 431, 172—6, 7
crassolamellata, Diploastrea, 117, 42—17, 18
crassula, Campeloma, 487
crassus, a, um, Bellerophon, 443, 178—21, 22
Botrybocrinus, 155, 57—23
Buchia, 395, 153—13, 14
Cyprimeria, 425
Derbyia, 345, 133—20, 21
Dictyonema, 65, 20—11
Eucalyptocrinites, 201, 75—24
Fenestella, 263
Hesperonomia, 297
Heterocrinus, 143
Iocrinus, 143, 52—15; 53—2
Obolella, 287
Pachydictya, 270, 102—5
Platystrophia, 299, 113—32–35
Poteriocrinites, 155
Rhombopora, 267, 101—7, 8
Seminola, 503, 207—17, 18
cratera, Palaeomanon, 53, 15—18
Siphonia, 53
craterigera, Jonesina, 679, 285—24–27
crawfordiana, Cancellaria, 514, 211—24
crawfordsvillensis, Cosmetocrinus, 159, 58—14
crenatus, a, Gyrodes, 483, 198—10–12
Natica, 483
crenimarginatus, Microptychis, 461, 186—28, 29
crenistria, Goniatites, 571, 234—4, 5
crenistriata, Philhedra, 293, 109—32, 33
crenulatus, a, Pecten, 403

crenulatus, Poleumita, 475, 194—13
crepidiformis, Jonesella, 667, 281—21–23
  Leperditia, 667
crescentis, Bairdiolites, 685, 288—8, 9
cretaceus, a, um, Busycon, 501, 206—15, 16
  Cassidulina, 41, 10—9
  Ceratobulimina, 39, 10—6
  Cytherura, 689, 291—23, 24
  Diploschiza, 407, 163—3–6
  Globigerina, 41, 11—1
  Globotruncana, 43, 11—9
  Gümbelitria, 33, 8—2
  Meretrix, 427, 170—19
  Ostrea, 395, 154—6, 7
  Protobusycon, 501, 206—15, 16
  Rectogümbelina, 33, 8—3
  Tornatellaea, 515, 212—10, 11
cribraria, Micrabacia, 117, 43—14, 15
cribriforme, Coscinium, 270, 102—13, 14
cribrosa, Stictoporella, 269, 101—36, 37
crickmayi, Kanastephanus, 585, 241—13, 14
crispus, a, Crispella, 327, 125—18–20
  Spirifer, 327
cristagalli, Ostrea, 395
cristatus, a, um, Arabellites, 229, 91—8
  Cavusgnathus, 245, 94—75–78
  Cochlespira, 513, 210—31
  Dibolbina, 675, 283—37, 38
  Orthonotacythere, 693, 292—35
  Phacops, 651, 274—16, 17
  Pleurotoma, 513
  Uvigerina, 35
  Valvata, 487
criticus, Torynifera, 327
croneisi, Ascoceras, 537, 218—9
  Nucula, 375, 145—30, 31
  Nuculopsis, 375, 145—30, 31
crotalum, Orthoceras, 541
  Spyroceras, 541, 221—2
crucialis, Tetragraptus, 69
cruciformis, Staurognathus, 244, 94—19
crumenata, Entosolenia, 35, 6—15
crustula, Conularia, 79, 22—26
cryptodens, Coenites, 111, 39—13–16
cuboides, Atrypa, 313
cuccense, Trachyceras, 579
cuculloides, Arca, 383, 148—7
  Barbatia, 383, 148—7
cucullus, Acrolichas, 637, 270—19–22
  Acrolichas (var. ottawaensis), 637, 270—23, 24
  Lichas, 637
culbertsoni, Fasciolaria, 507, 208—10, 11
  Plestochilus, 507, 208—10, 11
culcitella, Acteocina, 515, 212—16–18
cullomensis, Triticites, 23, 3—5, 6
cultellata, Polypora, 264, 100—9, 10
cultratus, Robulus, 31
cultrijugatus, Spirifer, 323
cultrispira, Nerinea, 495, 203—7
cumberlandia, Turritella, 493, 202—9
cuneatus, a, um, Endodesma, 414, 165—13, 14
  Healdia, 683, 287—10
  Lingula, 285
  Oenonites, 229, 91—56
  Schizodus, 401, 159—3
  Terebratula, 309, 365
cuneiformis, e, Flabellum, 122, 46—4
  Flabellum (var. lerchi), 122, 46—5
  Flabellum (var. pachyphyllum), 122, 46—8
  Kochoceras, 551, 226—8, 9
  Textularia, 17
cuneus, Conocardium, 389, 150—15–17; 151—1
cupula, Mamillopora, 276
curiosa, Clisiospira, 439, 176—1, 2
currieri, Kootenia, 613, 257—5
curticei, Coosella, 621, 264—28
curticei, Olenoides, 613, 256—4
curtus, a, um, Alabina, 497, 203—18
  Amphigenia, 363, 141—53–55
  Bairdia, 683
  Corynoides, 71, 21—88
  Lucina, 423, 168—26, 27
  Lunulacardium, 385, 149—15
  Pseudomonotis, 393, 152—25
curvatus, a, um, Homotrypa, 257
  Ieriodus, 245, 94—62
  Salterella, 531, 217—3
curvicostatus, Timorites, 577
curvidens, Oenonites, 229, 91—51
curvilata, Caryocaris, 657, 279—3, 4
curvilineatus, a, um, Acus, 511
  Acus (var. calvertensis), 511, 210—21
  Acus (var. dalli), 511, 210—19
  Acus (var. whitfieldi), 511, 210—22, 23
  Bellerophon, 443
  Terebra, 511
  Terebra (var. calvertensis), 511, 210—21
  Terebra (var. dalli), 511, 210—19
  Terebra (var. whitfieldi), 511, 210—22, 23
  Tropidodiscus, 443, 178—10, 11
curvilirata, Acus, 511, 210—20
  Terebra, 511, 210—20
curvirostra, Stenotheca, 701, 297—5
curvirostratus, Typhis, 503, 207—10
cuspidatus, a, um, Aechmina, 665, 280—53
  Arabellites, 229, 91—16
  Tellina, 415
  Triplesia, 307, 117—12–16
cuvier, Inoceramus, 389
cuvieri, Lemintina, 491
cyclolobus, Goniatites, 567
cyclopyge, Agnostus, 601
cyclostomus, a, Hudsonospongia, 53, 15—10–12
  Straparolus, 465, 188—3–5
cyclurus, Phaethonides, 641
cylindraceus, a, um, Bulla, 515
  Chaetetes, 103
  Ptilopora, 265, 100—19, 20
cylindratus, Palaeostylus, 461, 187—11
cylindricus, a, um, Argilloecia, 687
  Bythocypris, 683, 287—46–49
  Caryocystites, 125
  Cryptothyrella, 331, 126—52–55
  Fusulina, 21, 23
  Megacystites, 125, 47—1
  Orthotheca, 525
  Pentamerus, 305, 116—7
  Pleurodictyum, 111, 40—4
  Rhizocrinus, 205, 79—2
cylops, Coscinium, 270
cymbiformis, Goniophora, 411
cymbula, Carinaropsis, 445, 180—3–5
  Derbyia, 345, 134—1–5
cymosus, Abrotocrinus, 159—60—1
cypha, Platystrophia, 299, 113—36, 37
cyrtiniformis, Tenticospirifer, 321, 121—41–44
cystica, um, Tortophyllum, 93, 29—1, 2
  Zaphrentis, 93
cystosum, Clathrodictyon, 59, 18—14
cytheriformis, Corbicula, 419, 167—17–19

D

dactyliformis, Phacelocrinus, 171, 60—7
dactylodus, Lumbriconereites, 229, 91—38
dactylus, Cheirocrinus, 145
  Halysiocrinus, 145, 147, 55—5
  Marsupiocrinites, 185
dahalacensis, Estheria, 660
daileyi, Hydreionocrinus, 163
  Lasanocrinus, 163, 63—14
dakotensis, Fusulinella, 21, 3—30–32
dalei, Hallopora, 261, 99—11

dalli, Ringicula, 515, 212—5, 6
Volutoderma, 509, 209—16, 17
dama, Oliva, 511
danae, Bellinurus, 707
Euproöps, 707, 300—5
Melonites, 217
Oligoporus, 217, 82—17–19
Unio, 399, 158—13, 14
danianus, Hyolithes, 525, 215—14
danvillensis, Cytherelloidea, 687, 289—3
Hopkinsina, 37, 8—20
dattonensis, Amphissites, 671, 282—36
davidis, Paradoxides, 615, 254—12, 13; 300—13, 14
davidsoni, Eoradiolites, 421, 168—16
Murchisonia, 459
Prismatophyllum, 95
Radiolites, 42, 168—16
Trachypora, 109
davisi, Larvia, 302—24–29
Lingula, 285
dawsoni, Bathyuriscus, 613
Dawsonia, 609; 252—10–12
Kootenia, 613, 257—6
Microdiscus, 609
decabrachiatus, Phacelorinus, 171, 60—6
decacostata, Glyptopleura, 681, 285—48
decadactylus, Dimerocrinites, 187
Glyptocrinus, 199
decaturensis, Asrtocoenia, 115, 42—15
decewi, Euomphalus, 465
Pleuronotus, 465, 189—10, 11
decipiens, Hyolithes, 525, 215—50–52
decisa, Acila, 375, 146—11
Panope, 433, 172—21, 22
Truncacila, 375, 146—11
deckeri, Reedops, 653, 274—14, 15
declivis, Cythere, 689
Tellina, 429, 170—27
decora, Beyrichia, 677
Zygobolba, 677, 284—15, 16
decorata, Bolivinoides, 33, 8—6
decorticatum, Blothrophyllum, 97, 31—5, 6
decurtata, Ditomopyge, 645, 275—1, 2
decussata, Actinopteria, 391, 152—18
Crenella, 413
Palastraea, 119, 43—20
Virgiana, 307, 115—25–27
defectus, a, um, Campylorthis, 297, 111—36–41
Euprioniodina, 240, 93—66
Mesophyllum, 101
Strophomena, 297
deflecterus, Geodites, 56, 16—23
defontii, Defonticeras, 585, 241—6, 7
deformata, Archinacella, 469, 191—16, 17
deformis, Inoceramus, 389, 151—16
Tegulifera, 351
degrasensis, Talbotina, 633, 266—29–31
dekayi, Dipleura, 643, 272—26–31
Eutrephoceras, 549, 225—1–3
Eutrephoceras (var. mortonense), 549
Leiopteria, 383, 149—5
Nautilus, 549
delicatula, Corynotrypa, 250, 95—3
Hexactinellida, 56, 16—32–35
Hippothoa, 250
Palmatodella, 244, 94—18
Tetralobula, 301, 114—16–19
Tolypammina, 15, 1—10
Wellerella, 315, 120—32–34
delicatus, a, um, Dichocrinus, 197, 78—2
Idiognathodus, 246, 94—56–58
Ligonodina, 241, 93—74
Paracardium, 373
delphicola, Loxonema, 461, 186—17, 18
delphinocephalus, Trimerus, 654, 272—33
delphinuloides, Helicites, 453
deltisulcata, Octonaria, 682, 286—28, 29
deltoidea, Rafinesquina, 337, 129—23
demissus, a, um, Angulodus, 240, 93—58
Caritodens, 383, 148—16
Pecten, 405
Pterinea, 383, 148—16
Stropheodonta, 339, 131—12–14
Strophomena, 339
denckmanni, Grypophyllum, 95
dendrina, Helopora, 258
dendroidea, Astraea, 117
dendroides, Polypora, 264
densatus, a, um, Plicatula, 407, 163—8, 9
Pugnellus, 497, 203—27, 28
Strombus, 497
densus, um, Pachyteuthis, 595, 250—6–8
Syringostroma, 61
dentatus, a, um, Buskopora, 255, 96—24
Diplograptus, 73, 21—4, 5
Glyptograptus, 73, 22—4, 5
Hollinella, 669
Rhynchotrema, 309, 118—11–13
Synbathocrinus, 151, 55—16
denticulata, Marginella, 509, 210—5
dentifera, Primitia, 675
deperditus, Lumbriconereites, 229
depressicollis, Cadulus, 523
depressus, a, um, Ampullina, 481
Aphelaspis, 619, 263—35, 36
Carboprimitia, 679, 285—1–4
Conocephalites, 619
Cyprimeria, 425, 169—21, 22
Echinites, 221
Gyrodes, 483, 198—20
Heterostigina, 33
Isonema, 471
Roubidouxia, 447, 180—7
Schizobasis, 480, 197—4, 5
Spiroloculina, 27
Vaginella, 517
derbiensis, Pentremites, 137
descostilsii, Cellepora, 276
deshayesi, Micraster, 226
desideratus, a, um, Archaeocrinus, 183, 73—14
Bonniella, 607, 256—6, 7
Dorypyge, 607
Elkania, 285, 107—18, 19
Murchisonia, 459, 186—1, 2
Obolella, 285
Olenoides, 607
Schuchertella, 343, 132—46–48
desmophyllum, Balanophyllia, 122, 46—12, 13
desplainense, Lechritrochoceras, 545, 222—13
Trochoceras, 543
devoniana, Atrypa, 319, 121—16–18
devonicus, a, um, Gosselettia, 387
Hemicystites, 131, 49—23
Ichthyocrinus, 183, 68—17
Turrilepas, 695, 293—4
deweyi, Trigonocallista, 427, 170—6, 7
diabloensis, Parafusulina, 25, 4—16, 17
diabola, Hyalostella, 56, 16—16
diagonis, Trochammina, 29, 5—19
dianthus, Cyathophyllum, 93
Serpula, 231
dichotomus, a, um, Alecto, 250
Camarocladia, 56, 17—1–3
Diamespora, 271, 103—1–3
Heteropora, 251
Lithodendron, 119
Panenka, 373, 145—9
Staurograptus, 69, 21—10
dickersoni, Turbinolia, 121, 45—14–17
didyma, Arenicola, 234
diegoana, Calyptraea, 487, 199—37
diffugiaeformis, Urnulina, 13

diffugiformis, Proteonina, 13, 1—1
diffusa, Pseudohornera, 263, 99—17, 18
  Retepora, 261
digitatus, a, um, Archeolithothamnium, 302—34
  Coscinopleura, 271, 273, 103—22
  Hastigerina, 41
dignatus, Allagecrinus, 149, 56—10
digonum, Triboloceras, 547, 223—11, 12
dilatatus, Coeliocrinus, 159, 55—18
  Poteriocrinus, 159
dilatus, Acheilops, 619, 263—9–11
dilleri, Cidaris, 219, 83—4
dimidius, Inoceramus, 389, 151—3, 4
dininni, Echinocrinus, 217, 82—4, 5
diodon, Eunotia, 301—8
directus, a. um, Ensis, 431, 173—2, 3
  Polytylites, 673, 283—10
  Volsella, 413, 164—15
discoidalis, e, Elphidium, 33, 7—9
  Trepospira, 453, 183—21–23
discoideus, a, um, Paradoceras, 567, 231—14, 15
  Platycrinites, 203, 77—26, 78—22
  Tornoceras, 567, 231—14, 15
  Wilsonicrinus, 185, 72—26
discors, Euomphalus, 475
disculus, Sciadiocrinus, 165, 64—7
discus, Anthracoceras, 571
  Microcyclus, 85, 23—15–18
  Nomismoceras, 571
  Plaxocrinus, 163, 63—6
disjunctus, Cyrtospirifer, 321, 122—1–3
dislocata, Strioterebrum, 511, 210—18
  Terebra, 511, 210—18
dispansus, Edriocrinus, 205, 79—33
dispar, Avicula, 385
  Columnal, 209, 79—9
  Kochaspis, 611, 257—17–19
  Loxopteria, 385, 149—18, 19
disparilis, Atrypina, 319, 121—29
distans, Cardioceras, 585, 242—3–5
  Reptolunulites, 275, 104—1
distincta, um, Ceramoporella, 253, 96—7
  Leonardophyllum, 89, 25—26–28
distorta, Tessarolax, 499, 204—12, 13
  Trucherognathus, 239, 93—2, 3
divaricatus, a, um, Dicellograptus, 71, 21—23
  Fimbrispirifer, 323, 123—1, 2
  Nucula, 375
divergens, Amphoracrinus, 191, 77—28
diversa, Nuculana, 377, 146—34
dixonensis, Vanuxemia, 381, 147—15, 16
dockumensis, Antediplodon, 399, 158—3
  Unio, 399, 158—3
dodecaspinosa, Acanthosphaera, 48, 14—28
donaciformis, Tancredia, 421
doricum, Orthoceras, 539
doris, Paracardium, 373, 145—15, 16
  Springericrinus, 157, 58—12
dornickhillica, Monoceratina, 693, 292—31, 32
doronicum, Anthocyrtium, 48, 14—21
dosin, Chama, 427
douglassi, Elliptio, 399, 158—5, 6
  Hypselocrinus, 169, 60—8
  Rhodocrinites (var. serpens), 185, 73—9
  Unio, 399, 158—5, 6
douvillei, Ancyloceras, 589
dowlingi, Unio, 399, 158—9
downingiae, Acaste, 635, 274—13
  Calymene, 635
draco, Bolivina, 33
dracon, Ceratolichas, 641, 270—25–27
drakei, Titusvillia, 55, 16—5
dryope, Eotomaria, 455, 184—18, 19
dubius, a, um, Aurinia, 508
  Daonella, 393, 153—1
  Keratophytes, 264
dubius, Orthis, 355
  Paradelocrinus, 173, 62—31; 65—21
  Perditocardinia, 355, 139—30-34
  Polygnathus, 245
  Voluta, 508
dufrenoyi, Ammonites, 589
dumbli, Pharcoceras, 549
dumosus, a, um, Cardium, 425, 169—7, 8
  Cavaria, 251
  Granocardium, 425, 169—7, 8
  Lapparia, 508, 209—12, 13
  Mitra, 508
  Partretocyclocrin, 251, 95—18, 19
  Platyceras, 473, 193—15, 16
dunbari, Lophophyllidium, 87, 25—8–11
  Neospirifer, 325, 125—7, 8
duodactyla, Chirognathus, 237
dupini, Nerinella, 495
duplex, Ildraites, 231, 91—74, 75
duplicatus, a, um, Neverita, 483, 198—6
  Pugnoides, 315, 120—18–21
  Siphonodella, 245
  Siphonognathus, 245
durkeei, Corbicula, 419, 167—13, 14
dutertrei, Orthis, 341
dyeri, Glyptocrinus, 199, 73—23

E

eatoni, Schroederoceras, 543, 221—11
  Triarthrus, 654, 276—23
ebdome, Chancia, 609, 255—2, 3
ebenina, Clathrodrillia, 514, 211—10
eborea, Tellinimera, 429, 171—6, 7
  Yoldia, 379, 146—36
eburnea, Sertularia, 250
echinata, Clavagella, 415
echinophora, Buccinum, 500
edgewoodensis, Dalmanella, 353, 138—28–30
edsoni, Reuschella, 355, 139—40–42
  Rustella, 293, 110—4
edulis, Mytilus, 413
  Ostrea, 395
edwardsi, Dendrograptus, 67
egerius, Trochocyathus, 121, 45—3, 4
eggeri, Ventilabrella, 33, 35, 8—4, 5
ehrlichi, Ammonites, 581
eifelensis, Orthis, 353
elaborata, Balanophyllia, 122, 46—14–16
elax, Palaeostrophia, 301, 114—7–12
elderi, Lingula, 285
eldonensis, Hybocystites, 151, 53—1
electra, Orthis, 295
elegans, Arabellites, 229, 91—7
  Adrianites, 575
  Atrypa, 319, 121—8, 9
  Bergeronia, 617, 253—9
  Callograptus, 65
  Conocephalites, 607
  Craspedodiscus, 301—39
  Culmicrinus, 159, 59—9
  Didymograpsus, 71
  Elasmonema, 471, 192—22, 23
  Eratocrinus, 165, 59—12; 61—13
  Eschara, 273
  Fenestrellina, 263, 99—22, 23
  Hapalocrinus, 203
  Heliolites, 103, 34—17
  Hemizyga, 463, 187—18
  Hyperamminoides, 13, 1—3, 4
  Macraster, 225, 226, 88—1
  Mataxa, 515, 211—33, 34
  Nemagrapsus, 71
  Nucleocrinus, 135
  Orria, 613, 259—1, 2
  Paltodus, 240, 93—34, 35
  Prioniodus, 241, 93—53

elegans, Productus, 349
Protaxocrinus, 177, 68—14
Prothyris, 369, 144—7
Protolenus, 617, 253—9
Spiropora, 251
Zeacrinus, 165
elegantissima, Buliminella, 35
elegantulus, a, um, Aspidopora, 257, 97—16, 17
Callopora, 261
Cardium, 415
Cosmetocrinus, 159, 58—6, 21
Crenella, 413, 164—20, 21
Gondolella, 244
Hallopora, 261, 99—6, 7
Orthis, 353
Ostrea, 395, 154—8, 9
Streptognathodus, 246
Trachypora, 109, 38—16, 17
elephantinum, Dentalium, 521
elevatus, a, um, Delthyris, 327
Erisocrinus, 173, 65—27
Limacina, 517, 213—22-24
Tylostoma, 483, 189—34
eliasi, Lophamplexus, 87, 25—14-19
elimatus, Ammonites, 585
elizabethaeformis, Dichotomosphinctes, 587, 242—10-12
Perisphinctes, 587, 242—10-12
elleri, Aulopora, 113, 40—6
ellipsoclefta, Thlipsurella, 682, 286—19-21
ellipticus, a, um, Baetrites, 565
Legumen, 429, 171—12
Mesocena, 11, 14—18
Paracyclas, 423, 168—15
Polypora, 264, 100—14
Tetratylus, 683, 287—12-14
elongatus, a, um, Amphigenia, 363, 141—49-52
Anthracomya, 399, 155—8, 9
Archaeorthis, 295, 110—43-46
Armonia, 605, 255—21
Asaphiscus, 605
Atrypa, 363
Blainia, 605
Brahmacrinus, 200, 77—18
Cradeocrinus, 158, 53—18
Cylindrophyllum, 95, 30—8
Hypseloconus, 439, 175—16
Myrtillocrinus, 153
Naiadites, 399
Paryphorhynchus, 311
Pentamerus, 363
Pentremites, 134, 50—10
Rensselaeria, 363, 142—1, 2
Subulites, 477, 195—26
Terebratulites, 364
elytroides, Colpocaris, 657, 279—20-24
emaceratus, Cornellites, 383, 148—21
emaciata, Fenestrellina, 263, 99—26, 27
Hollinella, 669, 282—16-18
Schwagerina, 25, 4—27, 33
emarginatus, a, um, Echinodiscus, 223
Koenenia, 377, 146—24
Palaeoneilo, 377, 146—24
emersoni, Spathiocaris, 659
eminula, Natica, 485
emmetensis, Chonetes, 347
Longispina, 347, 135—1, 2
emmonsi, Apheoorthis, 295
Canadocystis, 125, 47—3, 4
Cymbophora, 431, 171—24, 25
Emmonsia, 107, 38—1-5
Favosites, 107
Hypothyridina, 315, 120—1-4
Orthotheca, 525, 214—38-40
emoryi, Trigonia, 401, 159—14
encrinoides, Graphiocrinus, 171
Turritella, 491, 201—7, 8
endlichi, Camarotoechia, 313
Paurorhyncha, 313, 119—20-22
ensiformis, Ensis, 431, 172—17, 18
Gervillia, 389
Gervilliopsis, 389, 150—13, 14
eocenensis, Chiton, 527, 216—15, 16
Trachyodon, 527, 216—15, 16
eos, Eurekia, 625, 265—4-6
Hipponicharion, 657
ephippium, Anomia, 409
epidermata, Emmonsia, 109
epigona, Rzehakina (var. lata), 27, 5—1
Silicina, 27
epsilon, Rutilaria, 301—27
equalis, Carposphaera, 48, 14—29
Cytherideis, 689, 290—31, 32
Heilprinia, 507, 208—14
equilateralis, Tellina, 429, 170—22
equistriata, Pseudomonotis, 393, 152—23
erebus, Peritrochia, 575, 236—22
erectus, a, um, Acodus, 239
Avicula, 383
Glyptodesmia, 383, 149—7, 8
Pararca, 373, 145—19, 20
eriensis, Cyttarocrinus, 203, 77—22
Eurypterus, 707, 299—12, 13
Platycrinus, 203
erinacea, Honeoyea, 385, 149—20, 21
Pulvinulina, 37
eriopis, Echinolichas, 645, 270—15, 16
Lichas, 645
eros, Chancelloria, 55, 16—12, 13
erratica, Stropheodonta, 339, 131—5, 6
eryon, Orygmaspis, 629, 266—33, 34
eschrichtii, Bittium, 495, 203—14
esthetica, Sinutropis, 465
estrellanus, a, um, Lyropecten, 407, 162—3, 4
Lyropecten (var. terminus), 407, 161—20
Pallium, 403
Pecten, 407, 162—3, 4
Pecten (var. terminus), 407, 161—20
eteminicus, Paradoxides, 615, 254—1, 2
etheridgei, Schizoblastus, 135, 51—24-26
etna, Euconia, 449, 181—24
Pleurotomaria, 449
eucharis, Camarospira, 333, 127—28-31
Devonaster, 211, 80—9-11
Gennaeocrinus, 191, 75—22
Orthambonites, 295, 110—47-50
Palaeaster, 211
eudora, Eospirifer, 321
eufaulensis, e, Aenona, 429, 171—1, 2
Cardium, 425, 169—9, 10
Meretrix, 427, 170—11, 12
Nemodon, 379, 146—49
Tellina, 429
Trigonia, 401, 159—12, 13
eugeneae, Pleurodictyum, 111, 39—20, 21
eugenium, Naedyceras, 561, 230—9
Trochoceras, 561
euglyphus, Diplograptus, 73, 22—2
Glyptograptus, 73, 22—2
eumus, Bynumia, 621, 263—34
euprepes, Architectonica, 491, 200—16-18
Pseudotorinia, 491, 200—16-18
eurekensis, Moorefieldella, 315, 120—35-37
Rhynchonella, 315
eurita, Eschara, 275
eurydice, Straparollina, 469, 192—14, 15
euthysepta, Fusulinella, 21
Wedekindellina, 21, 3—27-29
evansana, Trigonia, 401, 159—10
evansi, Actinocrinus, 191
Alsataspis, 637, 274—1
Arroges, 497
Drepanochilus, 497

evansi, Yoldia, 377, 146—40, 41
evansii, Megistocrinus, 191, 75—11
evax, Homoeospira, 361, 141—25–27
Rhynchospira, 361
evergreenica, Cytheretta, 688, 291—1
ewersi, Galateacrinus, 165, 64—14
exactus, Oenonites, 231, 91—49
exaltata, Turritella, 493, 202—17
exanthemata, Cythereis, 688, 289—44–48
excavatus, a, um, Bactrognathus, 243, 94—13, 14
Cytherea, 425
Spandelina, 17, 2—5
Sycotypus, 503, 206—21
excelsus, Oenonites, 231, 91—72
Protarabellites, 231, 91—69
Streptognathodus, 246, 94—73, 74
excentralis, Beleminites, 595
excentricus, a, um, Columnal, 209, 79—14
Dendraster, 223, 85—16, 17
Scutella, 223
excolata, Stensiöina, 39, 9—5
exempta, Diploneis, 301—2
exigua, Atrypa, 317
Breviarca, 379, 146—52, 53
Taeniopora, 270, 102—25, 26
exile, Dolorthoceras, 553, 226—6
eximius, a, um, Climacograptus, 73
Fusulina, 21, 23, 3—15, 20
Meekopora, 255
expansus, a, um, Actinocrinites, 179
Actinostroma, 59, 18—7
Aulocaulis, 113, 40—13
Aulopora, 113
Axophyllum, 89
Dolatophycus, 717, 303—28, 29
Gyrodes, 483, 198—21, 22
Icriodus, 245, 94—63
Kallimorphocrinus, 149, 56—4
Lumbriconereites, 229, 19—34
Praenatica, 473, 194—36
Pterotheca, 445, 180—15, 16
Taxocrinus, 177
Tegminal, 209, 79—17
expatiatus, Porites, 109
explanata, Pleurocora, 119
Stenoscisma, 315, 120—41–45
explanator, Cassinoceras, 535, 218—17
Piloceras, 535
explicatus, Crepicephalus, 623, 262—12
explicita, Dendropora, 111
exporrectus, a, Anomites, 321
Cyrtia, 321, 121—38–40
expressus, Lasiocrinus, 158, 53—14
exsculptus, a, um, Apographiocrinus, 158, 58—8
Onychocrinus, 179, 69—19
Rotalia, 39
exsul, Cheirurus, 641
extans, Asaphus, 639
Atrypa, 307
Bathyurus, 639, 267—37
extensus, a, Arachnocrinus, 153, 57—29
Burnetia, 621, 263—24
extinctorium, Caryophyllia, 122
exuta, Chesterella, 679, 285—14, 15

F

faba, Argilloecia, 687, 288—39—41
Indiana, 657, 278—8–12
fabulites, Leperditia, 664, 280—1–4
fairbanksi, Echinarachnius, 223, 84—10
fairchildi, Sinutropis, 465, 189—12, 13
falcatus, a, um, Alectryonia, 395, 154—10, 11
Eunicites, 229, 91—32
Ostrea, 395, 154—10, 11
falcicosta, Thomasatia, 669, 281—53
falcifer, Harpoceras, 583
falciformis, Anchura, 497, 203—26
Escharopora, 267, 101—20, 21
fallaciosa, Uncinulina, 313
falx, Goniatites, 569
fannini, Fanninoceras, 585, 241—11, 12
farnsworthi, Aphetoceras, 541, 221—9
farri, Lampsilis, 399, 158—4
Unio, 399, 158—4
fasciatus, Macrostylocrinus, 200, 74—7
fasciculata, Pterinea, 383
fasciger, Spirifer, 325
fastigiata, Beyrichia, 679
fatuum, Eunema, 451, 182—37
Trochonema, 451, 182—37
favonium, Flabellum, 122
favosus, a, um, Eulepidina, 47, 12—19, 20
Favosites, 1, 105, 107, 36—10–12
Lepidocyclina, 47, 12—19, 20
favulosa, Bythocypris, 682
Favulella, 682, 286—37–41
favus, Nidulites, 57
fayettensis, Endelocrinus, 173, 62—20; 65—4
Eupachycrinus, 173
fecunda, Ctenodonta, 375, 146—8, 9
Palaeoneilo, 377, 146—23
felchi, Unio, 399, 158—1, 2
fenestrata, Protospongia, 53, 16—6
Thecosmilia, 117, 43—32, 33
fernglenensis, Dictyoclostus, 350, 136—4–6
ferratus, um, Ephippioceras, 545, 223—4, 5
Nautilus, 545
ferrieri, Omphalotrochus, 467, 191—5–7
ferrisi, Lichas, 649, 270—17, 18
fertilis, e, Batostoma, 259, 99—1, 2
Resserella, 353, 138—10
festinata, Nisusia, 293, 110—5–7
Orthisina, 293
fialar, Glochiceras, 585, 241—8–10
fibratum, Tetradium, 101, 103, 34—12–16
fibristriata, Mytilarca, 387, 149—31
fibrosa, Hindia, 53, 16—1
fibula, Dictyocha, 11, 14—15
ficulneus, Fusus, 501
ficus, Murex, 500
Strepsidura, 501, 205—21
fieldensis, Bonnia, 607, 256—13, 14
filicatus, Latirus, 508, 208—13
Peristerina, 508, 208—13
filifer, Douvillina, 341
Stropheodonta, 341
filiformis, Hederella, 251, 95—11
filitextus, a, Mourlonia, 457, 184—36
Pleurocystites, 129, 48—20, 21
filosus, a, um, Geisonoceras, 537, 219—7, 8
Goniospira, 449
Murex, 507
Orbicula, 291
Pentremitidea, 134, 135, 50—23
Schizocrania, 291, 109—16–18
Terebratulina, 365, 143—41
fimbriatus, a, um, Ammonites, 581
Beyrichiopsis, 685
Delthyris, 327
Elytha, 327, 126—1–3
Pachydictya, 270, 102—1, 2
Phragmolites, 443, 178—6, 7
Siphonina, 39
finalis, Dicellocephalus, 643
Diplapatokephalus, 643, 267—42, 43
finkelnburgi, Finkelnburgia, 298
fiscellus, Gilbertsocrinus, 187, 73—4
fischeri, Chonetes, 347
Chonopectus, 347, 135—15, 16
Coenites, 111, 39—19
Elysastraea, 119
fissicosta, Plectorthis, 299, 112—41–43

fissurata, Chesterella, 679
fissurella, Styliolina, 526, 215—53
fissus, Agnostus, 600
Cancer, 701, 297—16
Tomagnostus, 600, 251—7, 8
flabella, Cornellites, 383, 148—18
Palaeopinna, 387, 150—12
flabellaris, Homotrypa, 257, 97—9, 10
flabellata, Diastoporina, 250, 95—12
flabelliformis, e, Dictyonema, 65, 173, 20—6
Dictyonema (var. anglica), 65, 20—3
Tonkinella, 617
flabellites, Atrypa, 319
Dolerorthis, 297, 111—6–8
Leptocoelia, 319, 121—26–28
flaccidus, Graptolithus, 71
flaminea, Mitrella, 500
flemingi, Chonetina, 347, 135—11, 12
fletcheri, Eutaxocrinus, 177, 68—10
Loxoconcha, 691, 291—32
Paleocyclus, 85
Sphaeropthalmus, 633, 262—3–6
flexilis, Onychaster, 213, 81—9–15
flexuosus, a, um, Cornulites, 233, 92—17
Dendrograptus, 67, 20—19
Glyptopleurina, 681, 286—1–3
Ptilodictya, 269
Striatopora, 109, 39—5, 6
flintensis, Proporocyclina, 47, 12—9
Pseudophragmina, 47, 12—9
florealis, Amygdalocystites, 125, 127, 47—9–11
Cyathocrinus, 161
Dasciocrinus, 161, 61—4
Hardouinia, 225, 86—10–12
Stellarocrinus, 157, 60—14
florida, Constellaria, 259, 98—16–20
floridanus, a, um, Anomocytheridea, 689, 290—23–25
Cytheridea, 689, 290—23–25
Eupatagus, 226, 87—22–24
Fragilaria, 301—29
Gunteria, 18, 2—15–17
Latirus, 508, 208—12
Orthophragmina, 47, 13—19
Terebratulina, 365, 143—1–3
fluminalis, Tellina, 419
fluviorum, Viviparus, 485
foedissima, Dentalina, 13
fohsi, Globorotalia, 43, 11—8
foliaceus, Diplograptus, 73
Graptolithus, 73
Metatirolites, 579, 238—8–10
Tirolites, 579, 238—8–10
foliata, Dichotrypa, 270
follis, Anomoeoneis, 301—17
Plasmopora, 103, 35—6–8
fontinalis, Bulla, 519
forbesi, Orbiculoidea, 291
forbesianus, Endolobus, 547, 223—17, 18
Mespilocrinus, 181
forillonia, Gaspelichas, 647, 271—20, 21
formosus, a, um, Bathyuriscus, 607, 258—11
Dielasma, 364, 143—11–13
Orthoceras, 539
Perimestocrinus, 161, 64—3
Phanocrinus, 171, 65—32
Rhynchospirina, 361, 141—14–18
Sphaerium, 419, 167—8, 9
Sphaerium (var. whiteavesi), 419
Synerocrinus, 179, 56—20
Waldheimia, 361
Zeacrinus, 171
fornicatus, a, um, Bairdiolites, 685, 288—19, 20
Barrandella, 303, 114—56–58
Crepidula, 489, 199—42, 43
Cribroconcha, 685, 288—21–23
Oenonites, 231, 91—57, 58
fornicatus, Patella, 489
fornix, Dictyocha, 11
fortis, Calicantharus, 503, 207—14
Cantharus, 503, 207—14
fossata, Polygnathodella, 246, 94—70, 71
4-costatus, Fusus, 505
14-brachialis, Eupachycrinus, 175, 64—33
foveatum, Sycidium, 716, 303—3
foveolata, Heterostomella, 18, 2—12
fractus, Telephus, 653
fragilis, e, Avicula, 385
Helopora, 265
Inoceramus, 389, 151—6
Lepidocyclina, 45, 13—11, 12
Lunulacardium, 385, 149—16
Nephrolepidina, 45, 13—11, 12
Pterochaenia, 385, 149—16
Sinum, 481, 198—1, 2
francescae, Orthosurcula, 514, 211—9
frankfortensis, Hebertella, 299, 112—52, 53
fraterna, Isocardia, 425, 169—18, 19
frechi, Agathiceras, 575, 236—12, 13
fremonti, Hamites, 583, 240—12
Idiohamites, 583, 240—12
frondicullariformis, Sigmomorphina, 32, 7—4
frondosa, Ceramophylla, 253, 96—15, 16
Clathropora, 267, 101—32–34
Phyllodictya, 269
Proboscina, 250, 95—14
fruticosa, Bythopora, 258
fucanus, Chlamys, 407, 161—21, 22
Pecten, 407, 161—21, 22
fulcrata, Solenodella, 244, 94—5
fulgur, Endoceras, 535, 217—20
fulminula, Ceraunocochlis, 477, 196—1, 2
fultonense, Cyrtorizoceras, 559, 229—6, 7
funkhouseri, Perprimitia, 667, 281—18, 19
furca, Thlipsura, 682, 286—12, 13
furcifera, Cladophyllia, 119, 43—26–28
furcillatus, Thamniscus, 264, 100—17, 18
furcula, Lyramula, 11, 14—7, 8
fusiformis, e, Allonema, 250, 95—9
Busycon, 501, 206—12, 13
Proteonina, 13
Pugnellus, 497, 203—30–32
Velumella, 273, 103—25
fusoides, Conomitra, 509, 210—2, 3
Mitra, 509
fusulinoides, Schwagerina, 25

G

gabbi, Crassatellites, 419, 167—5
Nuculana, 377, 146—32
Orthaulax, 499, 204—18–20
Saccella, 377, 146—32
galeati, Arcestes, 581
galericulum, Cytheropteron, 693, 292—15
gallatinensis, Ehmania, 611, 255—18, 19
galtensis, Eotomaria, 455, 184—20
ganti, Peritrochia, 577, 236—20, 21
gardnerae, Lepidocyclina, 45, 13—17, 18
Polylepidina, 45, 13—17, 18
garretti, Clithrocytheridea, 689, 290—15–17
Cythereis, 688, 289—49–51
Cytheridea, 689, 29—15–17
gaspensis, Acrospirifer, 323, 123—9–11
Etymothyris, 363, 142—5–7
gaspiensis, Stricklandia, 307, 117—48
gastrodes, Pteria, 391, 152—10
gebhardi, Lepocrinites, 128, 49—5, 6
geikiei, Oryctocara, 613, 259—8
geinitzi, Allorisma, 414, 165—1
geinitzianus, a, um, Chonetes, 347
Gladiolites, 75
Graptolithus, 75
Lissochonetes, 347, 135—13, 14

geinitzianus, Retiolites, 75
Retiolites (var. venosus), 75, 22—15, 16
Terebratula, 359
gemmiformis, Pisocrinus, 147, 54—14
gemmuliferus, Asaphus, 651
generosa, Panope, 433, 172—20
geniculatus, a, um, Dactylogonia, 341, 132—14, 15
Drymocrinus, 145, 52—7
Heterocrinus, 145
Logocrinus, 169, 58—1
Polytylites, 673, 283—4–7
geometricus, a, Corbisema, 11, 14—6
Stellarocrinus, 157, 58—5
georgiana, Asterocyclina, 47, 12—10
Discocyclina, 47, 12—10
germana, Ptarmigania, 617, 258—13, 14
gettysburgensis, Acila, 377, 146—12
gibba, Cythere, 689
Globulina, 32, 7—2
Polymorphina, 32
gibberosa, Kloedenella, 677, 284—19, 20
gibberula, Ctenodonta, 373, 146—1, 2
gibbosus, a, um, Agassizocrinus, 177, 61—5
Arabellites, 229, 91—17
Doleroides, 299, 112—48–51
Endolobus, 545
Monopteria, 393, 152—27
Murex, 514
Mya, 413
Orthis, 299
Pleurotoma, 514
Trematospira, 361, 141—21–24
gibbsi, Dendraster, 223, 84—1, 2
gibbulus, Murex, 507
gibbus, Agnostus, 600
gibsonensis, Bythocypris,683, 287—64–66
giddingsei, Taxocrinus, 177, 69—13
giganteus, a, um, Anomalocaris, 655, 277—7
Arabellites, 229, 91—18
Caryophyllia, 93
Cucullaea, 379, 147—1, 2
Grypophyllum, 95, 29—24
Hormotoma, 459, 185—22
Orbitolina, 31
Paraschwagerina, 25, 4—21, 22
Protarabellites, 231, 91—70
Schwagerina, 25
Siphonophrentis, 93, 28—25, 26, 30, 31
Zaphrentis, 93
gigas, Isotelus, 1, 647, 268—2, 3
gilberti, Inoceramus, 389, 151—7, 8
Olenellus, 613, 253—2, 3
Sulcoretepora, 270, 102—15
gilbertsoni, Actinocrinus, 191
Goniatites, 575
girardana, Gyroidina, 39, 9—4
girtyi, Alcimocrinus, 167, 61—15
Amphissites, 671, 282—40–42
Aviculopecten, 401, 159—23
Fusulina, 21, 3—21, 22
Heritschia, 87, 25—12, 13
Linnarssonella, 289, 109—4–8
Nucula, 375, 145—26, 27
Nuculopsis, 375, 145—26, 27
Strophostylus, 475, 194—8–11
Zeacrinus, 167
glabella, Calyptaulax, 641, 273—24–26
Voluta, 509
glabra, Eteraspis, 611, 255—23, 24
Haplophragmoides, 15, 1—11
Marginulina, 31
Ostrea, 395, 154—24, 25
Palmatolepis, 245, 94—40
glandella, Cavellina, 685, 288—28, 29
glans, Cactocrinus, 193, 77—10
Dipterophyllum, 85, 23—31–33
glans, Gomphocystites, 129, 48—13, 14
Zaphrentis, 85
glansfagea, Centronella, 363, 141—56, 57
Rhynchonella, 363
glenni, Ornopsis, 507, 208—18
glenrosensis, Bairdia, 683, 287—21, 22
glenwoodensis, Protarabellites, 231, 91—64
globosus, a, um, Bumastus, 639, 269—1, 2
Cyclocrinites, 719, 303—22
Eiffelia, 55, 16—31
Pachylocrinus, 161, 60—17
Physa, 519
Pionodema, 299
globularis, Cantharus, 503
globulatus, Porpites, 83
globulina, Nummulites, 47
globulosus, a, um, Eoasianites, 573, 235—15–17
Gümbelina, 33, 8—1
Textularia, 33
glomerata, Archaeorthis, 295
gloria, Cytherella, 685, 288—32
glycymeris, Arca, 383
glyptus, Apical, 209, 79—24
Strotocrinus, 193, 77—9
godoni, Encrina, 134
Pentremites, 134, 50—14, 15
goldfussi, Alveolites, 105, 36—6–8
goldfussiana, Myalina, 393
goldringae, Pentremitidea, 135
goniata, Ceratocephala, 641, 271—14, 15
goniglypta, Raymondatia, 669, 281—58–60
goniolobus, um, Goniatites, 571
Goniologoceras, 571, 234—24, 25
goodelli, Nerinea, 495, 203—1, 2
goodlandensis, Bythocypris, 683, 287—42, 43
Frankeina, 15, 1—14
goodwini, Proliostracus, 615, 255—10, 11
gorbyi, Cyphocrinus, 187, 72—12
Goniatites, 567
Prodromites, 567, 232—10, 11
gordoni, Pseudocrinites, 128, 47—30–32
gothlandicus, a, Favosites, 105
Liljevallia, 343
gouldi, Dozierella, 385, 149—11, 12
Oxoplecia, 307, 117—7–11
gouldii, Bakewellia, 385
Cassidulus, 225, 86—7–9
Murchisonia, 459, 186—6–8
gracilens, Hormotoma, 457
gracilenta, Vauxia, 53, 55, 16—7, 8
gracilioides, Cancellaria, 514, 211—23
gracilior, Bactrites, 565, 231—4
gracilis, e, Anthrapalaemon, 697, 294—25, 26
Baculites, 583, 240—9
Beatricea, 63
Belodus, 240, 93—51, 52
Buthotrephis, 717, 303—21
Codaster, 134, 50—1–3
Coleolus, 526, 214—18
Corynoides, 71, 21—27
Cosmetocrinus, 159, 58—16
Cromyocrinus, 171
Dentalium, 523, 214—8–10
Dikelocephalus, 623, 261—3, 4
Eunicites, 229, 91—31
Graptolithus, 71
Halysites, 113, 41—1–3
Hapalocrinus, 203, 77—15
Hemizyga, 463
Hormotoma, 457, 185—12–17
Hyphantozyga, 463, 187—16
Meretrosulus, 301—4
Murchisonia, 457
Nemagraptus, 71, 21—26
Norwoodia, 629, 266—16
Pagecrinus, 158, 57—4

gracilis, Pentaramicrinus, 171, 64—30
Pteroconus, 241, 93—69
Sterioconus, 237, 93—16, 21
Streptognathodus, 246, 94—72
gracilistriatus, Meekoceras, 577, 237—9, 10
Tentaculites, 526
gracillimum, Lioclema, 259, 93—23, 24
graeca, Patella, 480
grafordensis, Endelocrinus, 173, 65—3
graftonensis, e, Graftonoceras, 543, 222—4, 5
Lituites, 543
grahamensis, e, Apterrinella, 29, 5—16, 17
Imitoceras, 573, 234—18, 19
Tolypammina, 29
grandis, e, Crucibulum, 487, 200—29, 30
Cyrtodonta, 381, 146—60
Encope, 223
Eunicites, 229, 91—27
Evactinopora, 270, 103—12
Lichas, 654
Ophileta, 449, 181—28, 29
Orbicula, 291
Psiloconcha, 371, 145—3, 4
Roemerella, 291, 109—25, 26
Terataspis, 654, 270—30
Trimerella, 287, 107—33
grandissima, Phyllocoenia, 117
granifera, Lemintina, 491, 201—1, 2
granistriata, Trematopora, 267
granopunctatus, Graphiodactylus, 681, 285—43–46
granosus, a, um, Allorisma, 414, 165—12
Coeloconus, 267, 101—28
Ctenobolbina, 669
Euphoberia, 701, 294—21
Parabolbina, 671, 282—13
Poulsenia, 615, 259—6, 7
granti, Acanthograptus, 67, 20—24
grantonensis, Aclisina, 463
granularis, Sphaerechinus, 89—24
granulatus, a, um, Cystaster, 129, 49—9, 10
Hemicystites, 129
Melosira, 301—26, 30
Stromatoporella, 61, 18—16
granulifer, Chonetes, 347, 134—24-26
granulifera, Batostomella, 258, 98—4–6
granulosus, a, um, Columnal, 209, 79—13
Cryptoblastus, 137, 51—27, 28
Delocrinus, 171, 65—13
Delthyris, 323
Dikelocephalus, 631
Eurekia, 625, 265—13, 14
Macrostylocrinus, 200, 74—6
Palaeaster, 211
Ptychaspis, 631, 262—18–21
Shumardia, 653, 267—8, 9
Spinocyrtia, 323, 123—6–8
Stinocrinus, 158
graphicus, Delocrinus, 173, 64—16
grapsoideus, Avitelmessus, 699, 296—1–4
gravida, Bruclarkia, 503, 206—17
Clavella, 503
gravis, Dolichometopsis, 609, 258—15
grayae, Prasopora, 257
graysonensis, Macrocypris, 683, 287—67, 68
grayvillense, Glabrocingulum, 455, 184—21–23
greenei, Anisocrinus, 181, 54—8
greeni, Euloxoceras, 553, 227—2, 3
Prolecanites, 567, 231—18, 19
gregarius, a, um, Asaphiscus, 607
Beyrichiella, 679
Blania, 607, 259—19
Brevispirifer, 323, 122—22–26
Bronteopsis, 639, 267—23
Cypricardella, 415, 166—3
Decadocrinus, 169, 60—18
Geisina, 679, 285—20
gregarius, Mircheldeania, 302—15
Spirifer, 323
Strophostylus (var. proeva), 473
greggi, Chlamys, 407
Pecten, 407
gregori, Dokimocephalus, 623, 264—38, 39
grignonensis, Lichenopora, 251, 95—29
grimesi, Spirifer, 325, 124—25–27
griscomi, Diodora, 480, 197—11, 12
grisea, Adeona, 276
grönwalli, Solenopleura, 615
grossarti, Anthrapalaemon, 697
gryphorhynchus, Anomia, 409, 163—24
gryps, Ceratolichas, 641, 270—28, 29
Lichas, 641
guadalupae, Astrocoenia, 115
Rhynchonella, 315
guadalupe, Placenticeras, 595, 249—9, 10
guadalupensis, e, Collenella, 302—35
Uncinuloides, 315, 120—49–51
Waagenoceras (var. guadalupense), 577, 237—4, 5
guelphensis, Fletcheria, 103, 36—3–5
guettardi, Astrea, 119
gunteri, Miogypsina, 48, 14—3, 4
Miogypsinopsis, 48, 14—3, 4
gurleyi, Dicellograptus, 71, 21—22
gyracanthus, Tentaculites, 526, 214—41, 42
gyratilineata, Polygnathus, 245
Polylophodonta, 245

H

hackberryensis, Clionolithes, 57, 17—18
haddonfieldensis, Breviarca, 379, 146—54, 55
haitiensis, Balanocrinus, 207, 79—4
haldemani, Proetus, 653, 274—6
halei, Crassatellites, 419, 167—12
haliotoides, Helix, 481
Platyceras, 473, 193—9
halli, Calceocrinus, 145
Dalmanites, 643, 273—7–10
Decadocrinus, 169, 59—8
Euspira, 483, 198—23, 24
Favistella, 99, 32—3, 8, 9
Heliophyllum, 97, 31—8–11
Lonchodomas, 649, 267—10–13
Loxobucania, 445, 179—11–14
Lunatia, 485, 198—29–32
Norwoodella, 629, 266—5, 6
Pecten, 407, 161—15, 16
Polinices, 483, 198—23, 24
Syncyclonema, 407, 161—15, 16
hallianus, a, um, Cyrtoceras, 557
Dendrograptus, 65, 20—15, 16
Echinocrinus, 217, 82—13–15
Graptolithus, 65
Zitteloceras, 557
hallii, Pecten, 405
hamatus, a, Arabellites, 229, 91—1
Bactrognathus, 243
hamblenensis, Aphelaspis, 619, 263—37
hamburgensis, Nanorthis, 295, 110—39–42
Orthis, 295
hamili, Elliptio, 399, 158—7, 8
Unio, 399, 158—7, 8
hamiltonensis, e, Agelacrinites, 131, 49—22
Anostylostroma, 59, 18—8, 9
Cyrtina, 359, 140—37–39
Goniophora, 413, 164—13
Protarabellites, 231, 91—63
Protobalanus, 695, 293—13
Streblotrypa, 267, 101—13, 14
hamiltoniae, Amplexus, 93, 29—9, 10
Craniops, 293
Dictyonema, 65, 20—13
Favosites, 107, 37—6–8
Loxonema, 461, 186—16

hamiltoniae, Parallelodon, 379, 146—44
Petrocrania, 291, 109—28–30
hammelli, Ctenobolbina, 669, 281—66
hamulus, Idahoia, 625, 265—18, 19
handwerki, Eophacops, 645, 274—7, 8
Phacops, 645
hannai, Cytheridea, 693
Elphidiella, 33, 7—15
Orthonotocythere, 693, 292—42–45
hannibalensis, Grammysia, 371, 144—18, 19
hanseni, Leurorthoceras, 551, 226—4, 5
hanzawai, Pseudopolymorphina, 32
harangensis, Planulina, 43, 11—11
harlani, Arthrophycus, 719, 303—26, 27
Fucoides, 719
Oleneothyris, 365, 143—44–49
Paradoxides, 615, 254—3–7
Terebratula, 365
harrisae, Sciadiocrinus, 165, 62—17; 64—6
harrisi, Blothrocyathus, 117, 43—22–25
Clavator, 713, 303—14–16
Compsocrinus, 189, 75—20
Diploastrea, 117, 42—19
Glyptocrinus, 189
Helopora, 265, 100—31, 32
harrodsburgensis, Ceraunocochlis, 477, 196—3, 4
harroldi, Antispirifer, 325, 123, 17–19
hartleyi, Jaekelocystis, 127, 48—17–19
harttii, Gyroceras, 545
harveyensis, Mangelia, 514, 211—16
hastatus, a, um, Clio, 517, 213—32–34
Creseis, 517, 213—32–34
Orthoceras, 557
Tripteroceras, 557, 228—21–24
hausmanni, Asaphus, 649
hawkinsi, Miogypsina, 48, 14—1, 2
hawni, Eumicrotis, 393, 152—24
Pseudomonotis, 393, 152—24
haworthi, Fusulina, 21, 3—18, 19
Lepetopsis, 469, 191—11
hawthornense, Mandaloceras, 559, 229—12
haydeni, Anisomyon, 519, 212—32
Bathyurus, 607
Ostrea, 395, 153—24, 25
hayniana, Vanuxemia, 381, 147—13, 14, 17
headi, Athyris, 317
Catazyga, 317, 120—60, 61
healeyi, Patinopecten, 407, 163—2
Pecten, 407, 163—2
hearsti, Actinoceras, 551
Armenoceras, 551, 226—7
heckeli, Adeona, 276, 104—18
helderbergensis, Stereocrinus, 201
helderbergiae, Favosites, 107, 37—1, 2
helena, Albertella, 605, 258—1–3
helicina, Clio, 517
Turbo, 480
helicoides, Natica, 481
heliopelta, Actinoptychus, 301—36
heliopora, Astrea, 115
hemigranosus, Leiocidaris, 219, 226, 83—16; 89—1–3
hemiplicatus, a, um, Atrypa, 303
Enteletes, 347, 140—16–18
Parastrophina, 303, 114—44–47
hemisphericus (hemisphaericus), a, um, Calamopora, 107
Coelospira, 319, 121—22–25
Emmonsia, 107
Favosites, 107
Lithostrotionella, 89, 26—15–17
Megastrophia, 339
Platycrinites, 203, 205, 78—21
Poteriocrinus, 171
Terebratula, 365
henbesti, Glyptopleura, 681, 285—49, 50
henekeni, Fulgurofusus, 507, 208—19
herbichi, Sagenites, 581, 239—14–16
herbichi, Trachysagenites, 581, 239—14–16
hercules, Terebratula, 331
herricki, Bythopora, 258, 98—10–13
hertzeri, Hexameroceras, 561, 230—12, 13
hessensis, Hustedia, 363, 141—46–48
heteroclita, Calceola, 359
heterocostalis, Cupulocrinus, 155, 53—9
Scyphocrinus, 155
heterodactylus, Heterocrinus, 149, 52—11
heterophyllus, Ammonites, 581
heteropsis, Allorhynchus, 311, 118—66–68
Rhynchonella, 311
hewetti, Moorites, 673
hexagonus, a, um, Cyathophyllum, 95
Lagena, 32, 6—19
Mangelia, 514, 211—18, 19
hibbardi, Lumbriconereites, 229, 91—43, 44
hibernicum, Conocardium, 387
hicksi, Paradoxides, 615, 254—9, 10
hieroglyphicus, Melocrinites, 200
hildrethi, Schistoceras, 573, 235—11, 12
hilgardi, Micrabacia, 117, 43—7–10
hillanum, Cardium, 425
hilli, Perrinites, 577
Perrinites (var. hilli), 577, 237—1
Waagenoceras, 577
hindshawi, Cylindrophyllum, 95, 30—15
hindsii, Chiton, 527
hippocrepis, Scaphites, 591, 244—4, 5
hirsuta, Atrypa, 361
Cleiothyridina, 333, 128—1, 2
Parazyga, 361, 141—32–34
hirsutiformis, Productella, 349, 135—27, 28
hirundo, Mytilus, 391
hisingeri, Syringopora, 115, 42—1, 2
hispida, Chilotrypa, 255, 96—19, 20
historicum, Gyronema, 451, 182—29, 30
Trochonema, 451, 182—29, 30
hiwanneensis, Cytherella, 687, 288—42–45
Krithe, 691, 291—33–35
hoeferi, Paraceltites, 569
hollingsworthi, Staffella, 21, 3—39–43
holmesianus, Proparreysia, 399, 158—17, 18
Unio, 399, 158—17, 18
holopiforme, Acanthonema, 477
holstonensis, Oxoplecia, 307, 117—4
hopkinsensis, Taras, 423, 168—31, 32
hörnesi, Crisia, 250, 95—6–8
horni, Macrocallista, 427, 170—20
Pitar, 427, 170—20
horrida, Perimneste, 713
hortoni, Vallacerta, 11, 14—17
hoveyi, Hypselocrinus, 169, 60—21
Poteriocrinus, 169
howardi, Zophocrinus, 147, 54—20
howei, Siphonina, 39, 10—3
howelli, Clavaspidella, 609, 259—3
Ctenocephalus, 609, 253—13
hoyti, Pelagiella, 439, 175—19
huecoensis, Artinskia, 569, 232—14, 15
Schwagerina, 25, 4—18–20
humboldtensis, Ceratites, 579, 238—11–14
humboldti, Productus, 351
humerosus, a, um, Melania, 489
Paraparchites, 664, 280—27–30
Peyrotia, 493, 201—18
Pyrgulifera, 489, 200—5–7
Turritella, 493, 201—18
humifusa, Hernodia, 251, 95—25
humilis, e, Cupulocrinus, 155, 53—7, 25
Isonema, 471, 193—24
Petrosites, 51, 15—3
Protarabellites, 231, 91—65
Veniella, 417, 166—19, 20
hungerfordi, Theodossia, 321, 121—50, 51
hunterensis, Ophileta, 449, 181—33, 34

huntiana, Conularia, 77, 22—33, 34
huntsvillae, Taxocrinus, 177, 69—16
huronensis, e, Cyrtodonta, 381, 146—56, 57
Stromatocerium, 63, 19—11
hyatti, Acleistoceras, 559, 229—20, 21
Acrochordiceras, 579, 238—18–20
Dawsonoceras, 539, 220—8
hybrida, Ostrea, 405
Rhipidomella, 355, 139—5–7
hydrotheca, Plicatula, 407, 163—7
hystrix, Ammonites, 587
Atrypa, 319, 121—13

I

icarus, Ceraurinus, 641, 272—15
icosadactylus, Batocrinus, 195, 75—1
idahoensis, e, Acrotreta, 289, 108—34–39
Alokistocare, 605, 255—9
Drumaspis, 625, 264—31, 32
iddingsi, Olenellus, 615
Peachella, 615, 254—17
idonea, Glycymeris, 383, 148—12, 13
idrianus, Ceratites, 579
ignotus, Arachnocrinus, 153, 57—14
ilicifolius, Phyllograptus, 70, 21—9
illinoisensis, e, Dielasma, 364, 143—9, 10
Myalina, 393, 153—6
Stegocoelia, 459, 185—18
imago, Apiocystites, 128
Hallicystis, 128, 48—15
imbricata, Atrypa, 317
Atrypina, 319, 121—30–32
Ceramopora, 253, 96—12–14
Leptocoelia, 319
Monopleura, 421
Venus, 419
immaturus, a, um, Aorocrinus, 195, 76—9
Dorycrinus, 195
Wellerella, 315, 120—30, 31
impar, Hyolithes, 525, 215—10–13
imperator, Cactocrinus, 191, 76—8
imperatoris, Montastrea, 119, 44—7
imperfectum, Hemiphragma, 259, 98—26, 27
imperialis, Ciderites, 219
Leiocidaris, 219
implicata, Heterotrypa, 259
Monticulipora, 259
impolita, Anolotichia, 253, 96—18
impressus, a, um, Aulacoteuthis, 597, 250—9, 10
Centronella, 363, 141—58–61
Cythere, 691
Odostomia, 481, 197—22, 23
Perimestocrinus, 161, 62—8; 64—12
improcera, Arbacia, 221, 84—1–3
inaequalis, Krausella, 682, 286—48–50
Oistodus, 240, 93—44
inaequistriata, Douvillina, 341, 132—8–11
incepta, Polypora, 264, 100—12, 13
incerta, Operculina, 15
incilifera, Clathrodrillia, 514, 211—12
Clathrodrillia (var. angulata), 514
Clathrodrillia (var. distans), 514
incisurata, Sulcoretepora, 270, 102—16, 17
inclinatus, Polycaulodus, 239, 93—9
inclusa, Ceramoporella, 253, 96—5, 6
inconspicua, Rattrayella, 301—33
inconstans, Pleuromya, 413, 164—33
Vanuxemia, 381
incrassatus, a, Bolivina, 35, 8—17
Nautilus, 33
increbescens, Rhynchonella, 309
Rhynchotrema, 309, 118—14–16
Spirifer, 325, 124—6–9
incrustans, Paleschara, 271, 103—21
incurvus, Anomalocrinus, 151, 53—26
Forbesiocrinus, 179
indenta, Cypricardinia, 417, 166—10
Turritella, 493, 202—2, 3
independensis, Atrypa, 319, 120—69–71
indianensis (indianaensis), e, Actinocrinus, 197
Bythocypris, 683, 287—60
Comanthocrinus, 201, 75—21
Cyrtoceras, 551
Diestoceras, 559, 229—16, 17
Dizygocrinus, 197, 75—3
Elrodoceras, 551, 226—12, 13
Emperocrinus, 185, 72—14
Girtyella, 365, 143—24–26
Gomphoceras, 559
Harttina, 364
Kallimorphocrinus, 149, 56—5
Stegerhynchus, 309, 118—26–28
Stereocrinus, 201
indica, Lonsdaleia, 89
inelegans, Gigantoceras, 555, 228—3
Gyroceras, 555
Nautilus, 555
inexpectans, Protothalassoceras, 575
Sidneyia, 655, 279—36
inezana, Turritella, 493, 202—18
infera, Aulacella, 353, 138—24–27
infida, Diplotrypa, 257
inflatus, a, um, Corynotrypa, 250
Dictyoclostus, 350, 136—9–14
Fusispira, 477, 195—19
Hemizyga, 463, 187—17
Leperditia, 664
Martiniopsis, 329
Nautilus, 29
Olenoides, 613, 256—15, 16
Subulites, 477, 195—19
inflecta, Huronia, 553
Huroniella, 553, 227—5, 6
inflexus, Drepanodus, 239
informata, Schizoporella, 275, 104—8
infrequens, Cercidocrinus, 159, 60—20
infundibuliformis, Logocrinus, 169, 58—13
infundibulum, Natica, 483
ingricus, Trochiliscus, 713
iniqua, Glyptopleurina, 681, 285—58, 59
inoceriformis, Clementia, 425, 170—1, 2
Egesta, 425, 170—1, 2
inopinata, Glyptopleura, 681, 285—53–55
inornatus, Dichocrinus, 197, 78—7
Dimerocrinites, 187, 72—4
Gazacrinus, 189, 72—11
Orthaulax, 497
Paraparchites, 664, 280—26
inscriptum, Metengonoceras, 593, 248—4–6
insculptus, a, um, Glyptopleuroides, 681, 286—22
Glyptorthis, 297, 111—9–13
Melania, 489, 200—1
Orthis, 297
insignis, e, Bumastus, 639, 269—10–12
Clavulina, 18, 2—13
Escheria, 226
Hallia, 93
Linthia, 226
Orthis, 301
Pelecocrinus, 157, 58—10
Skenidium, 301, 113—7–12
insolens, Ctenobolbina, 671
Hollina, 671, 282—11, 12
intercalare, Placenticeras, 595, 249—6–8
interlineatus, Annuliconcha, 401, 159—18, 19
Aviculopecten, 401, 159—18, 19
intermedius, a, um, Archimedes, 264
Byssonychia, 385, 149—25, 26
Dalmanites, 645
Eomonorachus, 645, 273—30, 31
Ficus, 500
Girtyella, 365

intermedius, Hyolithes, 525
Orthotheca, 525
Taxocrinus, 177, 69—1
intermontanum, Pseudosageceras, 581, 239—12, 13
internascens, Anastrophia, 303, 114—53–55
internodius, Phacelocrinus, 171, 60—16
interplicata, Dolerorthis, 297
Orthis, 297
interpuncta, Favosites, 253
interradiatus, Anisocrinus, 181
interrasilis, Brachycythere, 688, 289—22
interrupta, Homotreta, 289, 108—40–43
Turbonilla, 481, 197—15
interscapularis, Platycrinites, 197
interstinctus, a, Heliolites, 103, 35—1–5
Stictoporella, 269
interstrictus, Agnostus, 600, 251—16, 17
intricaria, Pustulopora, 251
invisibilis, Nereidavus, 229, 91—47
iole, Dicellocephalus, 635
Tostonia, 635, 266—18, 19
ionensis, Aechmina, 665, 280—54, 55
iowensis, e, Cranaena, 364, 142—32, 33
Crepicephalus, 623, 262—7, 8
Cyathopora, 109
Cybeloides, 643, 271—22
Dikelocephalus, 623
Fusulinella, 21, 3—33, 34
Gilmocrinus, 169, 60—3
Goniatites, 573
Ischadites, 57, 17—27, 28
Isotelus, 647, 268—1
Lingula, 285
Paralegoceras, 573, 235—24, 25
Platyrachella, 325, 123—22
Schizophoria, 140—4, 5
Striatopora, 109, 39—8
ioxus, Bumastus, 639, 269—13, 14
iphigenia, Plaesiomys, 298
iridis, Neidium, 301—38
irrasum, Batostoma, 259
irregulare, Distoloceras, 587, 243—13, 14
irrorata, Balanophillia, 122, 46—10, 11
irvingi, Palaeacmaea, 437, 175—12, 13
islandicus, a, um, Nerita, 481
Pecten, 403
Venus, 417
israelskii, Pseudorbitoides, 45, 12—5, 6
isthmi, Lithothamnium, 302—33
italica, Saracenaria, 32, 6—9
ithacensis, Arthroacantha, 197
Eutaxocrinus, 177, 69—4
itys, Mourlonia, 457, 185—3

J

jacksoni, Calyptraphorus, 500, 204—5, 6
Ceratopora, 113, 40—15–17
jacksonica, Porella, 276, 104—11
jaekeli, Talanterocrinus, 181
jamesi, Plumulites, 695
jason, Cyrtoceras, 545
Nautilus, 543
Plectoceras, 543, 222—6
Ryticeras, 545, 222—15
jeffersonense, Mcqueenoceras, 533, 217—12
jeffersonius, Lyropecten, 407, 162—11
Lyropecten (var. septenarius), 407, 162—7
Pecten, 407, 162—11
Pecten (var. septenarius), 407, 162—7
jenneyi, Ancyloceras, 593
jerseyensis, Chonetes, 345, 134—27
Solenopleura, 635
Welleraspis, 635, 266—24
jesupi, Blothrocrinus, 158, 58—20
Poteriocrinus, 158
jewetti, Callocystites, 128, 48—1, 2
jewetti, Cupulocrinus, 155, 53—12
johanni, Rensselaeria, 364
Rensselandia, 364, 142—15
johnsoni, Argyrotheca, 365, 143—38–40
Chlamys, 407, 161—14
Pecten, 407, 161—14
jonesi, Isochilina, 664, 280—14–16
josepha, Pseudagnostus, 601, 251—5, 6
josephianum, Allumettoceras, 557, 228—14, 15
Sactoceras, 555, 227—9, 10
josephina, Neverita, 481
jucundus, Macrocrinus, 197, 76—18
juddi, Caninia (var. dawsoni), 91, 28—1-3
jukesi, Tetralichas, 654, 270—7, 8
junciforme, Leurocycloceras, 539, 220—2
juniperinus, Coenites, 111
jurassica, Solonopora, 302—30, 32
juresanensis, Productus, 350
justinae, Dufrenoya, 589, 243—15, 16
juvenis, Fulguroficus, 500, 205—13, 14
Priscoficus, 500, 205—13, 14

K

kankakensis, Austinella, 298, 112—1–3
Orthis, 298
kansasensis, e, Maeandrostia, 56, 17—10, 11
Malonophyllum, 87, 24—28–31
Paraschwagerina, 25, 4—23, 24
Protocaudina, 227, 90—14–16
Ulocrinus, 175, 56—26
kaskaskiensis, Agelacrinus, 131
Discocystis, 131, 49—19, 20
Orthotetes, 345, 133—5–8
keithi, Ceratopea, 447, 181—5–10
kellettae, Pseudozygopleura, 461, 187—8
kelloggi, Eurystomites, 541, 221—12
Nautilus, 541
kellumi, Neocomites, 587, 243—4, 5
Substeueroceras, 587, 242—16, 17
kennedyanus, Clavilithes, 501, 206—7
kentuckiensis, Actinocrinus, 191
Goniatites, 571, 234—9, 10
Punctospirifer, 361, 141—6, 7
Zygospira, 317, 120—54, 55
keokuk, Myalina, 393, 153—4
Orthotetes, 343, 133—1–4
Spirifer, 325, 124—14–17
kernahani, Stenoscisma, 315, 120—46–48
kernianum, Agasoma, 500
Trophosycon, 500
keyserensis, Clidochirus, 183, 69—18
Myelodactylus, 145, 54—27
kimmswickensis, Wellerocystis, 127, 47—14, 15
kingi, Conocephalites, 611
Conocoryphe, 611
Elrathia, 611, 255—5, 6
Graphiocrinus, 171, 65—18
kingianus, Anasibrites, 579, 238—1–3
Sibrites, 579
kingorum, Eothalassoceras, 575, 236—9, 10
kirbyi, Rhodocrinites, 185, 73—12
kirki, Daedalocrinus, 145, 52—7
Martiniopsis, 329, 126—36, 37
kjerulfi, Bryograptus, 69
klotzi, Ogygia, 613
Ogygopsis, 613, 258—16
knappi, Pentamerus, 305
Rhipidium, 305, 115—29, 30
knighti, Baylea, 453, 184—6, 7
Conchidium, 305, 116—5
Pentacrinus, 207, 79—3
Propinacoceras, 569, 232—8, 9
knoxense, Orthoceras, 553
Pseudorthoceras, 553, 227—1
koeneni, Aglaoglypta, 445, 179—19, 20
Bellerophon, 445

koeneni, Odontoceras, 587
koenigi, Cidaris, 219
kolmodini, Hollinella, 669, 282—1-3
koninecki, Actinocrinus, 197
Macrocrinus, 197, 76—17
Mespilocrinus, 181, 68—18
kothornostibus, Stibus, 682, 286—32-36
koureos, Galeodea, 500, 205—29
Mambrinia, 500, 205—29
krebsii, Architectonica (var. lampra), 491, 200—19-22
Psilaxis (var. lampra), 491, 200—19-22

L

labiatus, Inoceramus, 389, 151—15
labiosa, Coenites, 111, 39—17
Halliella, 665, 281—15-17
labradoricus, Obolus, 287
labrosus, a, um, Alokistocare, 607
Bolaspis, 607, 255—25, 26
Phanerotrema, 453, 183—24-26
Pleurotomaria, 453
labyrinthicus, Halysites, 113, 41—16, 17
lacerata, Solenodella, 244, 94—4
Solenognathus, 244
lachrymosa, Productella, 347
laciniatus, Entomostracites, 649
lacroixii, Membranipora, 271
lacunosus, Glyptocrinus, 183
Hemiaster, 219, 225, 87—10-12
Pachylocrinus, 161, 64—21
lacus, Dolatocrinus, 201, 74—20
lacustris, Eurypterus, 707, 299—10
laddi, Ephippiorthoceras, 539, 220—1
laelia, Philhedra, 293, 109—34
laeviceps, Eteraspis, 611, 255—20
Ptychoparia, 611
laevigata, Camerina, 33
Cassidulina, 41
Xenophora, 485
laevis, Agassizocrinus, 177, 61—8
Alisocrinus, 199, 74—2
Atrypa, 331
Bullopora, 32, 7—6
Cytocrinus, 200, 73—15
Ichthyocrinus, 183, 68—3
Leiopteria, 385, 149—2, 3
Lichas, 654
Macrostylocrinus, 200, 74—4
Martiniopsis, 329, 126—44-46
Pentamerus, 305, 116—1-4, 8, 9
Platycrinites, 203
Protaxocrinus, 177, 69—7
Pterinea, 383
laeviuscula, Exogyra, 397, 156—4, 5
laheei, Polytaxis, 31
lamarcki, Orthoceras, 533
Protocycloceras, 533, 217—10, 11
lambei, Gonioceras, 555
Lambeoceras, 555, 227—11
lamellatus, Paradoxides, 615, 254—14, 15; 276—19
lamellosus, a, um, Ambonychia, 387
Athyris, 333, 127—44, 45
Clionychia, 387, 150—5
Conopeum, 273, 103—13
Cumingia, 429
Cypricardinia, 417, 166—11, 12
Cyrtia, 321
Cyrtoceras, 557
Megambonia, 381, 147—23
Orbicula, 291
Spirifer, 271
lanceolatus, a, um, Flustra, 267
Oistodus, 239, 240, 93—23
Prothyris, 369, 144—8
lanii, Pterinea, 383, 148—17
lansingensis, Ditomopyge, 645
lapicida, Raphistoma, 447
Raphistomina, 447, 181—1, 2
lapworthi, Bryograptus, 69, 21—1
laqueatus, a, um, Coenites, 111, 39—18
Conchidium, 305, 116—6, 10-12
Ectinochilus, 497, 203—19
Pinna, 387, 150—7
larteti, Pleurotomaria, 457
larva, Ostrea, 395, 154—10, 11
lasallensis, e, Domatoceras, 549, 224—9, 10
Goniasma, 459, 185—21
Hypselocrinus, 169, 57—17
Marginifera, 351, 137—16-18
Murchisonia, 459
lasia, Haliotis, 480, 197—19, 20
lateralis, Spirifer, 325, 124—1-5
Syntrophia, 303, 114—29-31
Triplesia, 303
latericrescens, Icriodus, 245, 94—64
laticosta, Platystrophia, 299, 113—25, 30, 31
latifrons, Phacops, 651
latilirata, Chione, 427, 173—7-9
Venus, 427, 173—7-9
latissima, um, Cythere, 691
Cytheropteron, 691, 292—1, 2
latitruncata, Aclistochara, 713, 303—7, 8
lativia, Plethobolbina, 665, 280—58, 59
Primitia, 665, 280—58, 59
latus, a, um, Acontiodus, 239, 93—28, 29; 93—43
Cavellina, 685, 288—32
Coscinium, 270, 102—12
Doliognathus, 244, 94—50, 51
Euomphalus, 465, 188—15
Fenestella, 263
Hemitrypa, 263
Mastigobolbina, 675, 283—46
Stenopilus, 633, 260—8, 9
Straparolus, 465, 188—15
laura, Leiorhynchus, 313, 119—5-7
laurelianus, Carpocrinus, 193, 75—13
laxata, Favositella, 253, 96—10
laxus, a, um, Archimedes, 264, 100—6
Clathrodictyon, 61, 18—15
Serpulospira, 465, 188—2
Spirorbis, 231, 92—1-4
Straparolus, 465, 188—2
leachii, Cancer, 701
leavenworthana, Yunnania, 451, 183—7
leavenworthensis, Chaenomya, 373, 145—1, 2
lecontei, Trachyceras, 579
leda, Brachyprion, 339, 129—10
Bucanopsis, 443, 178—23
Devonoblastus, 135, 51—1
Loxonema, 461, 186—15
Pentremites, 135
Strophomena, 339
ledaforma, Brachycythere, 688, 289—19-21
leei, Fusulina, 21, 3—25, 26
legumen, Nautilus, 32
leidyi, Cypricardia, 660
Helix, 521, 213—9, 10
Leaia, 660
Planorbis, 519, 213—16, 17
leioderma, Athleta, 508
Leopeplum, 509, 209—14, 15
Volutilithes, 508
lens, Pecten, 405
Schuchertella, 343
Streptorhynchus, 343
lenticularis, e, Dosiniopsis, 427, 170—13-15
Pleurodictyum, 111, 39—25-27
Sphenodiscus, 595, 248—10-12
lentiformis, Euphemites, 445, 179—27, 28
leonardensis, Institella, 138—3-5
Productus, 351
leonensis, Cytherelloidea, 687, 289—4

leopoldinus, Ammonites, 589
lepidodendroides, Rhombopora, 265, 267, 101—4-6
lepis, Leptobolus, 285, 107—15-17
leprosa, Xenophora, 485, 199—10, 11
leptocalyx, Elibatocrinus, 159, 57—28; 62—23
levata, Ophileta, 449, 181—26, 27
levetti, Lepetopsis, 469, 191—3, 4
  Patella, 469
levinseni, Onychocella, 273
  Velumella, 273
levis, Stenotheca, 701, 297—6
lewisiana, Frustulia, 301—21, 22
lewisii, Lunatia, 485, 198—28
liliana, Crepicephalus, 611
  Kochaspis, 611, 257—16
lima, Ostrea, 407
  Terebratula, 365
limacoidea, Healdia, 682, 287—4-6
limaformis, Aviculopecten, 405
limatulus, a, um, Clathrodrillia, 514, 211—11
  Clathrodrillia (var. disimilis), 514
  Clathrodrillia (var. pyramidalis), 514
  Marginella, 509, 210—7
limatum, Girtyoceras, 571, 234—1-3
limitaris, e, Favosites, 107, 37—14, 15
  Leiorhynchus, 313, 119—42
limitis, Holectypus, 221, 226, 90—5
limonensis, Acrohelia, 121
limopsis, Volutilithes, 508
  Volutocorbis, 508, 209—7
limula, Pteria, 391, 152—9
limulurus, Dalmanites (var. lunatus), 643, 273—32
lindahli, Kirkbya, 673
  Kirkbya (var. arkansana), 681
  Savagella, 673, 283—8, 9
lindgreni, Trachyceras, 579
lindsleyi, Bellerophon, 445
  Loxobucania, 445, 179—9, 10
line, Cardium, 425
linearis, Fucoides, 234
  Schwagerina, 27
  Scolithus, 234, 92—34
lineatus, a, um, Entosolenia, 35
  Facetal, 209, 79—18
  Leptomitus, 51, 15—1, 2
  Metablastus, 135, 51—8
  Naticonema, 475, 194—6, 7
  Parafusulina, 27, 4—3-6
  Pentremites, 135
lineocosta, Apheoorthis, 295, 110—34-37
  Eoorthis, 295
lineolata, Hebertella, 301
  Mcewanella, 301
linguaeformis, Pteria, 391, 152—6
lingualis, Glossites, 371, 144—28
linguifera, Atrypa, 303
linneyi, Orthis, 309
  Orthorhynchula, 309, 117—41-47
linteus, a, um, Acteon, 515, 211—30, 31
  Cardium, 425, 169—17
  Crassatellites, 419
  Cymbophora, 431, 171—23
  Sulcocypraea, 500, 205—7, 8
lippa, Indiana, 657
liratus, a, um, Coloceras, 545
  Crepidula, 489, 199—44
  Dichocrinus, 199, 78—4
  Liroceras, 545, 223—8-10
  Lophospira, 449, 182—24
  Loxoplocus, 449, 182—24
  Neptunea, 505, 207—6
  Nucula, 375, 145—21
  Nuculoidea, 375, 145—21
  Paracyclas, 423, 168—14
listeri, Ammonites, 573
  Gastrioceras, 573, 235—1, 2
litterata, Oliva, 511, 210—11
littonanus, Strobeus, 479, 196—13
littoralis, Littorina, 489
llanoensis, Ptychoparia, 629
lobatus, a, um, Ammonites, 595
  Dawsonia, 609, 252—2, 3
  Physetocrinus, 193, 77—8
  Polygnathus, 245, 94—36
  Siphonodella, 245, 94—55
  Sphenodiscus, 595, 248—7
loculata, Ctenobolbina, 669, 281—70, 71
lodensis, Dikelocephalus, 631
  Saukia, 631
lodiensis, Brachymetopus, 639, 275—28
loeblichi, Oklahomacrinus, 167, 56—25
lofotensis, Rhizocrinus, 205
logani, Graptolithus, 69
  Loganograptus, 69, 31—3
  Maclurites, 469, 190—7-9 11-14
  Phacops, 651, 274—25, 26
loganianus, Ammonites, 587
  Seymourites, 587, 242—13
loganus, Protichnites, 719, 303—38
lommeli, Daonella, 393, 153—1
lomondensis, Triplagnostus, 600, 251—21, 22
lonense, Mesophyllum, 101, 33—14, 15
longa, Pteria, 391, 152—2
longicaudus, Proetus, 637, 275—23, 24
longiceps, Griffithides, 647
longicymba, Chiton, 527
longidactylus, Allocrinus, 200, 73—21
  Dendrocrinus, 155, 52—6
  Eocystites, 125, 47—7, 8, 27
longiforma, Pleurotoma, 514
longifrons, Yoldia, 379, 146—38, 39
longirostris, Uperocrinus, 197, 76—23
longispina, Acanthocrinus, 185
  Gervillia, 391
  Hollinella, 669, 282—5, 6
  Monopteria, 393, 152—26
longissimus, Serpulites, 79
longuronis, Glyptopleurina, 681, 286—4-6
longwelli, Palliseria, 469, 191—18, 19
lorrainensis, Climacograptus, 73
losboa, Bolis, 503, 207—15, 16
loveni, Paradoxides, 609
loxorhytis, Rafinesquina, 337, 129—19-22
lowei, Actinocrinites, 193, 76—4
lowryi, Gypidula, 305, 115—4, 5
lucasensis, Brevispirifer, 323, 122—17-19
lucerna, Phricodothyris, 327
lucina, Mourlonia, 457, 184—35
ludwigi, Ancistrum, 227, 90—21
lugubris, Alectryonia, 395, 154—4, 5
  Discinisca, 291, 109—22, 23
  Ostrea, 395, 154—4, 5
lumbricalis, Serpula, 491
lunatifera, Tetradella, 667, 281—39-43
lunatus, a, um, Arabellites, 229, 91—5
  Cancellaria, 514, 211—21
  Cymatosyrinx, 513, 210—37
  Pleurotoma, 513
  Scutellum, 653, 269—15
lurida, Astarte, 417
lutea, Cythere, 687, 289—9-12
lutheri, Anamesocrinus, 147, 56—12
  Goniatites, 565
  Probeloceras, 565, 231—5
lyelli, Periarchus, 221, 84—19-21
  Scutella, 221
lyoni, Anartiocrinus, 177
  Dolatocrinus, 201, 74—17
  Gissocrinus, 155, 55—12
  Goniatites, 567
  Protocanites, 567, 231—21-23
lyra, Coeliocrinus, 159, 57—1

lyroides, Dichotrypa, 270, 102—22–24

M

macbridei, Batocrinus, 195, 75—7
Spirifera, 325
maccabei, Hypselocrinus, 169, 60—9
macellus, Nautilus, 33
macer, Esmeraldina, 611, 252—19
Kloedenella, 677, 284—25, 26
macfarlani, Schizophoria, 357, 140—1–3
macilentum, Ectenochilus, 497, 203—20, 21
maclurii, Endopachys, 122, 46—20, 21
Turbinolia, 122
macoupinensis, Hypselocrinus, 169, 57—19
macrodactylus, Cyathocrinus, 177
macrolobatus, Dryphenotus, 245, 94—69
Gnathodus, 245, 94—69
macropetalus, Lecanocrinus, 181, 68—15
macrophora, Encope, 223, 86—1, 2
macrophthalmus, Pterygotus, 709, 299—3, 4
macropleurus, Eospirifer, 321, 121—56
Poteriocrinites, 155, 58—3
macroptera, Lima, 383
Limoptera, 383, 149—1
macrospira, Coeleocaulus, 459, 186—23–25
macrostoma, Bulla, 517
macrostriatus, Chonetes, 345, 134—16
madisonense, Trachyceras, 579
madisonius, Lyropecten, 407, 162—6
Pecten, 407, 162—6
madreporacea, Thamnopora, 109
maera, Aglaoglypta, 445, 179—16–18
magdalenensis, Ischnochiton, 527, 216—17–21
magister, Ethelocrinus, 175, 65—33
Eupachycrinus, 175
magnacurta, Bairdia, 683, 287—15, 16
magnicosta, Rhynchopora, 359, 140—27–30
magnicostata, Strophalosiina, 349, 135—38–40
magnificus, a, um, Acanthodiscus, 587, 243—8, 9
Aesiocrinus, 167, 56—32, 62—32
Arabellites, 229, 91—11
Chonophyllum, 101, 33—19–21
Eretmocrinus, 195
Leptostrophia, 341, 131—18, 19
Paludina, 487
Strophodonta, 341
magnilabris, Membranipora, 275
magnitubus, Nyctocrinus, 189, 77—23
magniventrus, Poteriocrinus, 157
Springericrinus, 157, 58—9, 19
magnoliaeformis, Cyathocrinus, 165
Zeacrinites, 165, 61—1
magnus, a, um, Campylorthis, 297
Ensis, 431
Maclurites, 467, 190—1–6
Marginirugus, 350, 135—52, 53
Monotrypa, 261, 99—3, 4
Oncoceras, 561
Productus, 350
Syntrophopsis, 303, 114—32–35
maia, Martiniopsis, 329, 126—34, 35
Murchisonia, 459, 186—4, 5
major, Acantherpestes, 701, 294—17, 22
Ameura, 637, 275—23, 24
Eunicites, 229, 91—28
Halymenites, 717, 303—20
Hormotoma, 459, 185—25–27
Irvingella, 627, 265—25
Lyrodesma, 401, 159—6, 7
Pinnularia, 301—18
Thecia, 109, 39—1, 2
majuscula, Spiropora, 251, 96—1
mallaeforme, Hercorhynchus, 507, 208—21, 22
maloniana, Astrocoenia, 115, 42—13, 14
mamillaris, e, Arachnophyllum, 101, 34—5
Calyptraea, 487, 199—35, 36
mamillaris, Polinices, 483
mammillatum, Ammonites, 591
Douvilleiceras, 591, 244—9
mammulata, Monticulipora, 255, 257
mandula, Beyrichia, 665
manitobensis, e, Cyrtoceras, 561
Maclurites, 469, 190—10
manitoulini, Tryblidium, 437, 174—2
mansfieldi, Kochiella, 613, 253—7, 8
mantelli, Lepidocyclina, 45, 13—16
Nummulites, 45
manus, Stinocrinus, 159, 60—15
marcellensis, e, Centroceras, 545, 223—1
Goniatites, 545
Orthoceras, 539, 220—6, 7
marcellusensis, Arabellites, 229, 91—21
marcida, Monopleura, 421, 168—9, 10
marcoui, Acheilus, 619, 263—8
Kootenia, 613, 257—10, 11
Xenaspis, 569, 233—3–5
margarita, Helix, 480
margaritiferus, Unio, 399
marginalis, Glauconome, 265
Plectatrypa, 317
marginatus, a, um, Bulimina, 35
Ceraurinus, 641
Kirkbya, 671, 282—20
marginicinctus, Marginicinctus, 349, 135—49–51
Productus, 349
maria, Meristella, 331
Meristina, 331, 127—12–15
mariae, Plectodonta, 335
mariannensis, Asterocyclina, 47, 12—18
Discocyclina, 47, 12—18
marlboroensis, Cytherella, 687, 288—48–51
marmoreus, Conus, 513
marrsae, Sellardsicrinus, 175, 64—29
marshalli, Anematina, 471, 192—16, 17
marshi, Dolatocrinus, 201, 74—22
Protocaris, 655, 277—2
martinezensis, Cibicides, 43, 11—12
Mesalia, 495, 203—5
martini, Dentalium, 521, 214—16
Laevidentalium, 521, 214—16
martyni, Bairdoppilata, 683
marvinwelleri, Orthonema, 477, 195—3, 4
marylandicus, a, um, Arca, 383, 148—9
Astraea, 121
Barbatia, 383, 148—9
Diodora, 480
Natica, 485, 199—2
Ophiura, 213, 81—16
Pecten, 407, 162—5
Placopecten, 407, 162—5
Raphidodiscus, 301—31
Rensselaeria, 363, 142—3, 4
Septastrea, 121, 44—17, 18
marysvillensis, Olivula, 511, 210—14, 15
matheri, Delocrinus, 171, 65—11
Elvinia, 625, 264—40
mathewsonii, Dosinia, 427, 173—1
matleyi, Camerina, 33, 7—10–12
matthewi, Paradoxides, 615, 254—11
matutinus, Hudsonaster, 211, 80—5
Synbathocrinus, 151, 56—22
maxima, um, Busycon, 501, 206—20
Gyroporella, 302—16–19
maxvillensis, Anartiocrinus, 177, 61—11
mayeri, Cytherideis, 689, 290—30
mazonensis, Anthraconectes, 707, 299—8, 9
Eurypterus, 707
mcgerriglei, Clarkella, 013
mcglameryae, Tubulostium, 234, 92—26–28
mcguirei, Pachylocrinus, 161
Plummericrinus, 161, 62—20

meguirei, Talanterocrinus, 181, 56—30
meguirti, Cythereis, 688, 289—34
media, Endothyra, 17, 1—17
Irvingella, 627, 265—26, 27
Orbiculoidea, 291
Orbitoides, 43
medialis, e, Atrypa, 311
Cumingia, 429, 171—13, 14
Cyclonema, 471, 192—27, 28
Eatonia, 311, 118—41–43
Lophospira, 451, 182—16–19
Loxoplocus, 451, 182—16–19
Strobeus, 479, 196—14
mediavia, Natica, 485, 199—3
mediaviense, Dentalium, 523, 214—24, 25
Graptacme, 523, 214—24, 25
mediocris, Oulodus, 244, 94—7, 8
medioseptata, Sowerbyites, 335
mediterranea, um, Solemya, 369
Stacheoceras, 577
medlicottianus, Aulosteges, 349
meduanensis, Craniella, 291
medulare, Orthoceras, 541
Protokionoceras, 541, 221—1
meedsi, Dinorthis, 298
Plaesiomys, 298, 111—52, 53
meeki, Daraelites, 569
Dosiniopsis, 427, 170—13–15
Flexicalymene, 645, 272—1, 2
Onniella, 353, 138—11–14
Parichthyocrinus, 179, 69—12
Placenticeras, 595
Resserella, 353, 138—11–14
meekii, Anisomyon, 519
megaera, Filifascigera, 251, 95—27, 28
Tubulipora, 251
megalostoma, Bellerophon, 441
megastoma, Heliolites, 103, 34—18
meigsii, Physa, 519, 213—4
melie, Lingula, 285
melissa, Lyriocrinus, 185, 72—28
melita, Apheoorthis, 295
melo, Cryptoblastus, 137, 51—32–34
Pentremites, 137
melonica, Mimella, 299, 112—44–47
membranacea, Estheria, 660, 279—13–15
menardensis, Macrocypris, 683, 287—69, 70
menardii, Pulvinulina (var. tumida), 43
meniscus, Astraeospongia, 57, 17—16, 17
Blumenbachium, 57
mensurans, Dicellograptus, 71, 21—19, 20, 31
mercenaria, Mercenaria, 427, 170—8, 9; 173—10, 11
Venus, 427, 170—8, 9; 173—10, 11
meretrix, Venus, 427
merriami, Flabellum, 121
Platytrochus, 121, 45—24–26
merrilli, Gondolella, 245, 94—32–34
mesacostalis, e, Leiorhynchus, 313, 119—4
Tylothyris, 323, 122—20, 21
mesal, Cerithium, 495
mesastrialis, Platyrachella, 325, 123—20, 21
mesenterica, Ostrea, 395, 154—16
meslerianum, Adelphoceras, 571
Girtyoceras, 571
mesolobus, Chonetes, 347
Mesolobus, 347, 135—6–8
metastriata, Linearia, 429, 171—3, 4
metra, Meteoraspis, 629, 265—42
Ptychoparia, 627
meyeri, Falsifusus, 507, 208—16
mexicanus, a, um, Balanocrinus, 207, 79—5
Caecum, 491, 200—26, 27
Cymbella, 301—9
Ochetoceras, 583, 240—17, 18
miamiensis, Compsocrinus, 189, 75—19
Cuneamya, 369, 144—16, 17
micans, Hyolithellus, 525, 214—32–36
Uncaspis, 635, 266—28
michaelis, Orthambonites, 295
michelini, Orthoceras, 537
Terebratula, 355
michiganensis, Aulopora, 111, 40—14
Porpites, 83, 23—6–8
micronema, Anomia, 409, 163—17
Arca, 383, 148—5, 6
Barbatia, 383, 148—5, 6
micronematodes, Desmograptus, 67, 20—17, 18
microphthalmus, Eurypterus, 707, 299—12, 13
microporus, a, Encope, 223, 86—3
Halysites, 113, 41—15
microscopica, Acrotreta, 289
microsphaera, Hexalonche, 48, 14—24
micrurus, Odontochile, 651, 273—3, 11
Odontochile (var. clarkei), 651, 273—12
micula, Liospira, 453, 183—1–6
Pleurotomaria, 451
midwayense, Cytheropteron, 691, 292—14
miliaris, Echinus, 221
millebrachiatus, Eucladocrinus, 205, 78—29
milleporaceus, Chaetetes, 103, 35—12–15
milleri, Bumastus, 639, 269—3–6
Echinus, 219
Lophospira, 449, 182—1, 2
Loxoplocus, 449, 182—1, 2
Murchisonia, 449
Sporadoceras, 567, 232—5–7
millingtoni, Mitra, 509
millipunctata, Trematis, 289, 109—9–12
millsapsi, Galeodea, 500, 205—26–28
milneri, Coelosmilia, 122
mima, Holopea, 473
mimica, Fenestrellina, 263, 99—25
mimula, Blountia, 619, 263—3, 4
minganensis, Archaeoscyphia, 51, 15—5, 6
Petraia, 51
Tetralichas, 654, 270—13, 14
minima, Lepidorbitoides, 45, 12—11
miniscaensis, Ptychaspis, 631, 262—1
minna, Cythere, 683
minneapolis, Cyrtoceras, 557
Cyrtorizoceras, 559, 229—4, 5
minnekahtensis, Jonesina, 681, 285—35–39
minnesotensis, e, Berenicea, 250, 95—16, 17
Dictyonema, 65, 20—1
Dikelocephalus, 1, 623, 261—7, 8
Homotrypa, 257, 97—6–8
Öpikina, 337, 129—11
Rhynchotrema, 309, 118—19–22
minor, Cedaria, 621, 264—1, 2
Cornulites, 233, 92—14
Fistulipora, 255
Lonchocephalus, 627, 265—22–24
Thecia, 109
minus, Hipponicharion, 657, 278—14
minuscula, Pionodema, 357, 139—43–45
minutissimus, a, Anematina, 471, 192—20, 21
Aparachites, 664, 280—21
minutistriatum, Dentalium, 523, 214—12, 13
Graptacme, 523, 214—12, 13
minutus, a, um, Girtyspira, 477, 195—13, 14
Glyptopleurina, 673
Leptozyga, 461, 187—10
Marginella, 509, 210—8
Meekospira, 477, 195—9
Moorites, 673, 283—12
Pseudozygopleura, 461
miocenica, Nonionella, 33, 7—8
Virgulina, 35, 8—14
Virgulinella, 35, 8—14
mirabilis, Cyclozyga, 463, 187—30
Petalocrinus, 153, 54—31
mirus, Sphaerexochus, 653

misa, Dikelocephalus, 631
Prosaukia, 631, 261—9–11
mississippiensis, Ampullina, 481, 197—31
Ampullinopsis, 481, 197—31
Buccinum, 505
Dorycrinus, 195, 76—6
Ficus, 500, 205—23
Mourlonia, 457, 185—1, 2
Murex, 505, 207—13
Protoscutella, 221, 85—10–12
Scutella, 221
Tritiaria, 505, 208—2
missouriensis, e, Anthracoceras, 571, 234—20, 21
Conularia, 77, 22—32
Culmicrinus, 159, 59—6
Cytherella, 685, 288—32
Delocrinus, 173, 62—24; 65—14
Dorycrinus, 195, 76—7
Goniatites, 573
Hystricurus, 647, 267—28, 29
Liroceras, 545
Lovenechinus, 217, 82—20
Oligoporus, 217
Orbiculoidea, 291, 109—24
Proetus, 653, 276—9, 10
Rhipidomella, 355, 139—11–15
Rhynchonella, 313
Scalarituba, 234
Schistoceras, 573, 235—9, 10
Shumardella, 313, 119—27–30
Tylothyris, 323, 122—11–14
mitella, Cyrtolites, 439
Cyrtonella, 441, 176—3–6
mitrata, Turbinolia, 121
modestus, a, um, Atrypa, 317
Bucanopsis, 443, 179—6–8
Chraspedops, 705, 298—4, 8, 9
Eoasianites, 573
Mastigobolbina, 675, 283—47, 48
Petrocrania, 291
Saffordia, 371, 144—31, 32
Zygospira, 317, 120—72
modiolaris, e, Modiodesma, 411, 164—6
Pterinea, 411
modiolus, Mytilus, 413
modulata, Aulopora, 113, 40—7, 8
mohri, Wellerites, 575, 236—7, 8
mojsisovics, Prolecanites, 567
mojsisovicsi, Waagenoceras, 577
moniliferum, Trigonopora, 276, 104—15
monmouthensis, Cytheridea, 689, 290—1–4
Haplocytheridea, 689, 290—1–4
montanaensis, Gervillia, 389, 150—11
Trigonia, 401, 159—15
montanensis, Clarkella, 301, 114—13, 14
Cymella, 415, 165—23
Eucladocrinus, 205
Nisusia, 293, 110—8–11
Polytoechia, 301
montereyi, Triceratium, 301—11
montfortianus, Bellerophon, 445
Cymatospira, 445, 179—34–41
montgomeryensis, e, Cytheridea, 689, 290—12–14
Cytheropteron, 693, 292—16–21
Haplocytheridea, 689, 290—12–14
Megaglossoceras, 545, 223—6, 7
Nautilus, 545
monticola, Cyrtospirifer, 321, 121—52
montifera, Glyptopleurina, 681, 286—8
montis, Agnostus, 600, 251—1, 2, 19
montosa, Kellettina, 673
montpelierensis, Nucula, 375, 145—32, 33
Waagenoconcha, 351, 137—35–38
moodeyi, Beyrichia, 675, 283—23–26
moorei, Triticites, 23, 3—3, 4
mooresi, Aatocrinus, 163, 63—10
moragai, Amaurellina (var. lajollaensis), 481, 197—30
moreauensis, Cuspidaria, 415, 165—27
moremani, Cytherella, 687, 288—46, 47
Quinqueloculina, 27, 5—4
moreyi, Aclistochara, 713, 303—6
Hollinella, 669, 282—4
morganopsis, Lepidocyclina, 47
morikeanus, Ammonites, 587
mormoni, Hustedia, 363, 141—43–45
Terebratula, 363
morrisonensis, Bairdocypris, 683, 287—57–59
Bythocypris, 683, 287—57–59
morrowensis, Allocatillocrinus, 149, 56—18
Griffithides, 651
Paladin, 651, 275—7, 8
morsei, Arca, 383, 148—8
Barbatia, 148—8
mortoni, Amusium, 407, 163—1
Callianassa, 699, 295—6–16
Lepidocyclina, 45, 13—1–3
Macropneustes, 226, 90—1–4
Pecten, 407, 163—1
Phyllacanthus, 219, 83—14, 15
Turritella, 493, 201—14–16
Turritella (var. postmortoni), 493, 201—17
mortonis, Pygorhynchus, 225
mosquensis, Avicula, 393
Gnathodus, 245
moussoni, Daonella, 393
mucronatus, a, um, Belemnitella, 597
Belemnites, 597
Delthyris, 321
Hallograptus, 75, 22—17
Lasiograptus, 75, 22—17
Mucrospirifer, 321, 122—4–6
mucrospinus, Aatocrinus, 163, 63—3
mudgeana, Margarites, 480, 197—6
Periaulax, 480, 197—6
muelleri, Cythere, 688
Cytheridea, 689, 290—9–11
muirheadi, Dibunophyllum, 87
multattenuata, Syringopora, 115, 42—5–9
multibrachiatus, Cactocrinus, 191, 77—2
Eudimerocrinus, 187, 72—6
Forbesiocrinus, 179, 68—4
multicameratum, Michelinoceras, 537, 219—1, 2
Tarphyceras, 541, 221—10
multicaule, Synaptophyllum, 95, 29—25–28
multicirrus, Camptocrinus, 199, 78—13
multicostata, Linearia, 429, 171—5
multicostum, Leiorhynchus, 313, 119—8, 9
multifasciàtus, Sphaerocystites, 128, 48—7, 8
multilinigera, Brachydontes, 413, 164—16
Volsella, 413, 164—16
multiloculata, Polytaxis, 31, 5—18
multiporata, Eumorphocystis, 129, 48—22–24
multiporus, a, um, Glyptocystites, 128, 129, 49—1–3
Melonechinus, 219, 83—1–3
Melonites, 217
multiradiatus, Actinocrinites, 193, 76—3
multisecta, Resserella, 353, 138—15–18
multispinata, Schackoina, 41, 11—5, 6
multistriatus, a, um, Campeloma, 487, 199—22
Schizophoria, 357, 140—10, 11
Spirifer, 361
Trematospira, 361, 141—28–30
multitabulata, um, Endoceras, 535
Hallopora, 261, 99—8–10
mumiaforme, Oncoceras, 557
Whitfieldoceras, 557, 229—1, 2
mundula, um, Aclistochara, 713, 303—9
Mitoclema, 251, 96—11
mundus, Bryantodus, 243, 94—21
munsteri, Avicula, 391
muralis, Pomatotrema, 298, 112—15–18
murchisoni, Acrospirifer, 325, 123—15, 16

murchisoni, Cyrtograptus, 77
Graptolithus, 70
Malocystites, 125, 47—12, 13
Palaeosmilia, 97
Strombodes, 101
Tetragonis, 57
murdercreekensis, Eucytherura, 691, 291—7, 8
muricatina, Marginifera, 351, 137—24–26
muricatus, a, um, Actinopteria, 391, 152—21
Amphiscapha, 465, 188—40–42
Straparolus, 465, 188—40–42
muricina, Volutilithes, 508
murrayanum, Loxonema, 461, 186—22
muscosa, Mopalia, 527, 216—35–37
musculosa, Rhipodomella, 355, 139—8–10
musica, Voluta, 508
muta, Palaeoneila, 377, 146—22
mutabilis, Aurinia, 508, 209—10, 11
Eridotrypa, 258, 98—21, 22
Gryphaea, 397, 155—12
Rhinidictya, 269, 102—6, 7
Volutomorpha, 509, 209—23
mutata, Camarotoechia, 311, 118—62–65
mutica, Olivella, 511, 210—12
myelodactylus, Camptocrinus, 199
myriophthalma, Astrea, 115
mytiloides, Modiolopsis, 409, 163—27
Modiomorpha, 409, 164—1
Lithophaga, 413

N

nacrea, Pholidostrophia, 341, 132—1–3
Strophodonta, 341
Strophomena, 341
nanus, a, um, Bucanella, 441, 176—18–20
Cosmetocrinus, 159, 58—15
Eunicites, 229, 91—23
Subulites, 477, 195—25
narrawayi, Hudsonaster, 211, 80—6
nashvillae, Uperocrinus, 195, 76—25
nasuta, Ctenodonta, 373, 146—5
Macoma, 429, 171—15
Meristella, 333, 127—26, 27
Rafinesquina, 337, 129—17, 18
Tellinomya, 373
natans, Cavolina, 517
natator, Barrandeoceras, 543, 221—13
Nautilus, 543
nautiloidea, Lituola, 17
navarroensis, e, Cytherella, 687, 288—46, 47
Cytheropteron, 691, 292—6, 7
Helicoceras, 593, 246—10
Robulus, 31, 6—3
Volutilithes, 508, 509
navia, Gryphaea, 397, 155—4, 5
navicula, Acanthoscapha, 682, 286—44
Beecherella, 682
Lenticulina, 31, 6—4
nealli, Reteocrinus, 183, 72—1, 8
neapolis, Hyolithes, 525, 215—47–49
nebrascana, Oxytoma, 391, 152—5
Pteria, 391, 152—5
nebrascensis, Cavellina, 685, 288—33, 34
Chlamys, 405, 161—7, 8
Juresania, 350, 137—1–3
Lingula, 285
Pecten, 405, 161—7, 8
Trigonocallista, 427, 170—4, 5
Trigonoglossa, 285, 107—21
nebulosa, Ptilodictya, 267, 101—35
neglectus, a, um, Cleidophorus, 377, 146—18, 19
Dimegelasma, 359, 141—1–5
Euchondria, 403, 160—11, 15
Fistulipora, 255, 96—21
Pecten, 403
Spirifer, 359
neglectus, Stegerhynchus, 309, 118—38–40
Strophomena, 337, 130—11–14
nelsonense, Westonoceras, 561, 230—2
neocomiensis, Ammonites, 587
neptuni, Receptaculites, 57
nereus, Decadocrinus, 169, 64—16
nervosa, Nervostrophia, 341, 131—22, 23
Strophomena, 341
nestor, Phragmoceras, 561, 230—10, 11
Phragmoceras (var. canadense), 561
neunia, Genevievella, 625, 265—10–12
nevadae, Proetus, 653, 276—8
nevadaensis, Schizophoria, 357, 140—6, 7
nevadana, Atrypa, 319, 121—6, 7
nevadensis, Amplexus, 93, 29—14, 15
Anomalorthis, 298
Desmorthis, 299, 112—34–39
Heterophrentis, 91, 28—13–15
Olenoides, 613, 256—18
Paradoxides, 613
newberryi, Acanthonema, 477, 195—22–24
Astartella, 417, 166—14
Bellerophon, 477
Gryphaea, 397, 155—19
Palaeopalaemon, 697, 294—12–16
Pholadella, 414
newelli, Trachydomia, 475, 194—31, 32
newsomi, Lyrogoniatites, 571, 234—13, 14
Lyrogoniatites (var. georgiensis), 571, 234—15–17
newton-winchelli, Clarkoceras, 533, 217—5
Piloceras, 533
nexus, Diplograptus, 73, 22—3
Orthograptus, 73, 22—3
niagarensis, e, Alveolites, 105
Bumastus, 639, 269—7–9
Calymene, 1, 641
Cheirurus, 641, 272—13
Conularia, 77, 22—27, 28
Cystiphyllum, 99, 33—1–5
Diaphorostoma, 473, 193—1, 2
Eospirifer, 321
Favosites, 107, 36—13–17
Leurocycloceras, 539, 220—3
Paleaster, 211, 80—1–4
Platyceras, 473, 193—10
Syringostroma, 61, 19—9, 10
nicholsi, Eleusoceras, 561, 230—5
nicholsoni, Achistrum, 227
Dicranograptus, 71, 21—32
Rhinidictya, 269
nicklesi, Carneyella, 131, 49—12
Paraparchites, 664, 280—22, 23
Streblotrypa, 267, 101—15–17
nicolleti, Discoscaphites, 589; 243—10–12
Protozyga, 317, 120—52, 53
nieszkowskii, Murchisonia, 459
nigro-spinatus, Alpheus, 298—10
nilssoni, Monograptus, 75, 22—24
nimbatus, Ammonites, 585
niternudia, Janira, 405
nitidium, Eunema, 451, 182—35, 36
Trochonema, 451, 182—35, 36
nitidulus, a, Aristerella, 411, 164—10, 11
Turrilepas, 695, 293—6
nitidus, a, um, Atrypa, 331
Crepicephalus, 625
Didymograptus, 70, 21—14
Dunderburgia, 625, 264—29, 30
Elrathiella, 611, 255—17
Kloedenella, 677, 284—21, 27–30
Loganellus, 625
Phanocrinus, 171, 64—35
Triarthropsis, 635, 266—7, 8
Whitfieldella, 331, 126—47–49
nivea, Turbonilla, 481, 197—14
noae, Fusus, 501

nobilis, Agnostus, 619
Architectonica (var. quadriseriata), 491, 200—23–25
Callipleura, 311, 118—69, 70
Forbesiocrinus, 179
Glyptocrinus, 187
Ichthyocrinus, 177
Megistocrinus, 191, 75—9
Parichthyocrinus, 177, 69—8
Rhynchospira, 311
Siphonocrinus, 187, 72—21
Weymouthia, 619, 252—16
nobilissimus, Ctenocrinus, 200, 74—15
nodocarinatus, um, Euphemites, 445, 179—32, 33
Tainoceras, 547
nodocostata, Grammysia, 371, 144—24, 25
Phillipsia, 637, 275—23, 24
nodopyga, Macraster, 225, 226, 89—15, 16
nodosarius, a, Bigenerina, 17
Myelodactylus, 145, 54—25
nodosus, a, um, Acanthoscaphites, 591, 246—3
Acanthoscaphites (var. brevis), 591, 246—1, 2
Acanthoscaphites (var. quadrangularis), 591, 246—4–6
Adinocrinus, 161, 60—25; 62—4
Ammonites, 579
Ancyrodella, 244
Echinocystites, 129
Halysiocrinus, 147, 55—9
Hydrotribulus, 503, 207—1, 2
Lysocystites, 129, 49—4–7
Megistocrinus, 191, 75—10
Melocrinites, 200, 74—10
Naticopsis, 475
Orestes, 455
Phymatopleura, 455, 183—37
Platycrinus, 203
Stephanozyga, 463, 187—13
Trachydomia, 475, 194—33–35
Zeacrinus, 161
Zygopleura, 461
noduliferus, Hydreionocrinus, 161
Perimestocrinus, 163, 62—9; 64—5
nodulosus, a, um, Beatricea, 63, 19—17, 18
Holaster, 225
Spirorbis, 233
Trachydomia, 475, 194—29, 30
noe, Loxonema, 461, 186—19, 20
nona, Clarkella, 303
norica, Montlivaltia, 117, 43—18, 19
normalis, e, Brachycycloceras, 539, 220—5
Kloedenia, 675, 283—34–36
Lonchodomas, 649, 267—14, 15
Mooreoceras, 553, 226—14, 15
norwalkensis, Dikelocephalus, 623, 261—1, 2
norwoodi, Orbitremites, 137, 51—37–41
notabilis, Ulrichospira, 451, 182—28
notans, Brachyaspis, 639, 268—22
nothus, Polygnathellus, 245, 94—46
novamexicana, Fusulina, 21, 3—23, 24
novascoticus, Chonetes, 345, 134—8, 9
nucleata, Anoplia, 347, 135—17–20
Leptaena, 347
nucleolatus, Uncinulus, 313, 119—35–37
nucleus, Arca, 375
Corbula, 431
Voluta, 508
nuculitiformis, Ribeiria, 659, 297—20–22
numisma, Astrea, 115
nuntius, a, um, Forbesiocrinus, 183
Spyroceras, 541, 221—4, 5
Synaptocrinus, 183, 68—7
nuptialis, Aporrhais, 499, 204—10, 11
Lispodesthes, 499, 204—10, 11
nutans, Strophomena, 337, 130—8–10
nycteus, Botryocrinus, 155, 57—9, 22

O

obesus, Homagnostus, 600, 251—9, 10
Pentremites, 134, 50—20, 21
Plaxocrinus, 163, 63—8
Pycnomphalus, 471
Typhis, 503
oblata, Rhipodomella, 355, 139—16, 17
obliquata, Whitella, 381, 147—18, 19
obliquus, a, um, Arthrostylus, 265, 100—15, 16
Ctenodonta, 375, 146—3, 4
Dentalina, 31
Eridotrypa, 258
Eridotrypella, 258, 98—28, 29
Nodosaria, 31
Oligoptycha, 515, 212—9
Phragmolites, 443, 178—3, 4
Welleria, 677, 284—43, 44
oblongatus, Nuculites, 377, 146—13, 14
oblongula, Acanthodesia, 273, 103—17
oblongus, a, um, Cypricardella, 417, 166—6
Pentamerus, 305
Pleurophorus, 415, 165—32
Surirella, 301—20
obnutus, Cadulus, 523, 214—27, 28
obovatus, Nucleocrinus, 135, 51—9
Paradelocrinus, 173, 65—22
obrapum, Busycon, 501
obscura, Dekayella, 258, 97—32–33
Elrathiella, 611
Syntrophopsis, 303
Terranovella, 635, 266—23
Thompsonaspis, 617, 256—8–10
obsolescens, Pentamerella, 305, 115—14, 15
obsoletus, a, um, Dallinella, 365, 143—42, 43
Euomphalopterus, 467, 191—8–10
Parallelodon, 379, 146—43
Terebratella, 365
Tetranota, 441, 177—20, 21
obtusispira, Omphalotrochus, 467, 191—12–15
obtusus, a, Bulimina, 35, 8—15
Homotelus, 647, 268—6, 7
ocalana, Heterostegina, 33, 7—14
Operculina, 33, 7—13
Valvulina, 18, 2—9
occidens, Disphyllum, 95, 29—22, 23
Oldhamia, 719, 303—17–19
Phanerotrema, 453, 183—27
occidentalis, e, Arctica, 417, 166—18
Arctinurus, 637, 271—17, 18
Aviculopecten, 401, 159—21, 22
Caprina, 421, 168—11, 12
Clonocrinus, 201, 73—13, 24
Conchidium, 305
Corbicula, 419, 167—20, 21
Fenestrapora, 263, 99—34
Hexacrinites, 197, 78—8
Lima, 409, 163—14
Lucina, 423, 168—22, 23
Orthopsis, 226, 88—21, 23
Pentamerus, 303
Pleurophorus, 415, 165—34
Receptaculites, 57, 17—24, 25
ocoyanus, a, um, Sycotypus, 500
Trophosycon, 500, 205—9–11
Turritella, 495, 202—16
octobrachiatus, Dichograptus, 69, 70, 21—4
Graptolithus, 69
octocostatus, Trochiliscus, 713, 303—1, 2
octoformis, Octonaria, 682
oculata, Hemitrypa, 264
oculifera, Ceratopsis, 669, 281—46, 47
oehersi, Glyptopleurina, 681, 285—60
ogarai, Plummericrinus, 161, 62—35; 63—19
ohioensis, e, Conocardium, 389, 150—18
Ilionia, 423, 168—13
Paracyclas, 423, 168—13

ohioensis, Trematoceras, 539
Trimerella, 287, 108—44-46
Triticites, 23, 3—13, 14
Tylorthoceras, 539, 219—13, 14
oklahomae, Linoproductus, 351, 138—1, 2
Ulrichicrinus, 158, 59—14
oklahomaensis, Bairdia, 683, 287—17
oklahomensis, Anomalorthis, 298
Avonia, 349, 135—46-48
Caryocaris, 657, 279—1, 2
Chonetes, 345, 134—17-20
Ethelocrinus, 175
oldhami, Cyclolobus, 577, 237—11, 12
Phylloceras, 577
oligoptilus, Dimerocrinites, 179
olisiponensis, Exogyra, 397, 156—6
olla, Apioceras, 559
Neverita, 481
olliculaeformis, Lecythiocrinus, 154, 53—21
olorum, Spyroceras, 541, 221—6
olsoni, Ditomopyge, 645, 275—3
omphalodes, Spirorbis, 233, 92—7
onangondiana, Andrarina, 605, 276—26
oneidaense, Acrophyllum, 99, 32—13
Clisiophyllum, 99
oniscus, Corbula, 431, 172—10, 11
onoense, Hypophylloceras, 581, 239—19
Phylloceras, 581, 239—19
ontarioensis, Nereidavus, 229, 91—48
onyx, Crepidula, 489
Hamulus, 233, 92—21-24
operculiformis, Entolium, 405, 161—1
Pecten, 405, 161—1
operculons, Ostrea, 403
ophirensis, Acrotreta, 289
ophiura, Asterias, 213
opima, Cucullea, 375
Nucula, 375, 145—22
Nuculoidea, 375, 145—22
oppletum, Vaginoceras, 535, 218—5, 6
optatus, Echinodiscus, 131
Prozacanthoides, 617, 257—8, 9
orbicularis, Cleiothyridina, 335, 128—6-8
Gyroidina, 37
orbiculatus, a, um, Avicula, 403
Lyriopecten, 403, 160—9, 10
Nautilus, 549
orbifera, Holoporella, 276, 104—16
orbignianus, Discotrochus, 117, 43—1-3
orbignyanus, a, Discotrochus, 117
Goniatites, 569
orbignyi, Hadrophyllum, 85, 23—24, 25
Heteraster, 225
orcas, Amphicyrtoceras, 559, 229—18, 19
Oncoceras, 559
orcutti, Coralliochama, 421, 168—17-19
ordovicica, Amorphognathus, 237
oregonensis, e, Callianassa, 699, 295—2-5
Phlycticrioceras, 589, 244—1, 2; 249—11, 12
orestes, Spirifer, 325, 124—18, 19
ornamentatus, Distephanus, 11, 14—19
ornatissimus, a, um, Atira, 480, 197—10
Cyathocrinus, 157
Cytherina, 688
Hallocrinus, 157, 57—24
Margarites, 480, 197—10
ornatus, a, um, Asaphocrinus, 181, 68—2; 69—17
Caryocrinites, 127, 47—22, 23
Corocrinus, 191, 74—3
Cyrtolites, 439, 175—24, 25
Dendropora, 111, 39—3, 4
Diploneis, 301—3
Encrinurus, 645, 271—3-7
Loriolia, 226, 89—17-19
Macrostylocrinus, 200, 74—13
Paraceltites, 569, 233—1, 2
ornatus, Patelliocrinus, 200, 73—16
Sphaerotocrinus, 185, 72—24
Taxocrinus, 177, 69—9
Trachypora, 109, 38—21, 22
orodes, Euryrizoceras, 559
orthia, Syntrophia, 301
orthoceroides, Harrisoceras, 539
orthodontus, Oenonites, 231, 91—60, 61
ortoni, Estheria, 660, 279—10-12
Triplesia, 307, 117—17-21
osagensis, Triticites, 23, 3—11, 12
Wellerella, 315, 120—27-29
osceola, Dikelocephalus, 629
Osceolia, 629, 262—9, 10
osculata, Goniobasis, 489
ostiolata, um, Chilotrypa, 255, 96—27-29
Clathrodictyon, 59
ostrearum, Clathrodrillia, 514
oswegoensis, Anisocrinus, 181, 54—7
ottawa, Isochilina, 664, 280—13
Leperditia, 664
ottawaensis, Eoharpes, 645, 267—1
ottawanus, Doleroides, 299
ottonis, Fusus, 507
ottumwa, Pugnoides, 315, 120—22-26
Rhynchonella, 315
ouachitensis, Polygnathodella, 246
ovalis, e, Agassizocrinus, 177, 61—9
Arabellites, 229, 91—2
Cylindrotopsis, 479
Hadrophyllum, 85, 23—26-28
Nematopora, 265, 101—12
Spirifera, 327
Taxocrinus, 177
ovatus, a, um, Arctica, 417, 166—16, 17
Baculites, 583, 240—6-8
Baculites (var. haresi), 583
Craniops, 293
Cypricardites, 409
Cytherella, 687, 288—46, 47
Cytherina, 687
Estheria, 660
Linoproductus, 351, 137—32-34
Multivasculatus, 55, 16—37, 38
Odontopleura, 651
Stromatotrypa, 259, 99—12, 13
Talarocrinus, 199, 78—11
Thalamocrinus, 153, 54—24
Thaleops, 654, 268—11-15
overana, Dakoticancer, 699, 297—15
oviformis, e, Apioceras, 559
Arabellites, 229, 91—14, 15
Gomphoceras, 559
Modiolodon, 411, 163—22, 23
Modiolopsis, 411
Ovoceras, 561, 230—7, 8
Plethomytilus, 387, 150—1
ovoides, Acteon, 515, 211—25
Rensselaeria (var. gaspensis), 363
ovula, um, Cadulus, 523
Nucula, 375, 145—36
owenanus, Ecculiomphalus, 467, 189—26, 27
oweni, Arionellus, 629
Crepicephalus, 629
Dikelocephalus, 623, 261—12
Goniatites (var. parallela), 571
Lophospira, 449, 182—10, 11
Loxoplocus, 449, 182—10, 11
Modocia, 629, 265—39-41
Platyrachella, 325, 123—23-26
Receptaculites, 57, 17—26
Rhipodomella, 355, 139—18-20
Trachydomia, 475, 194—27, 28
ozarkensis, Calvinella, 621, 261—15, 16

P
pacheoensis, Haustator, 493, 202—13, 14
  Turritella, 493, 202—13, 14
pachydactylus, Ctenocrinus, 200, 74—11, 14
  Patelliocrinus, 200
pachypleura, Epitonium, 481, 197—29
  Sthenorytis, 481, 197—29
pacificum, Cymatium, 505, 207—6
packardi, Astarte, 417, 166—27, 28
pagoda, Borestes, 455, 183—34
  Ectomaria, 461, 186—12, 13
pagurus, Cancer, 699
pahasapensis, Metacypris, 693, 291—43-46
pallettei, Pentremites, 134
palmatus, a, um, Astrhelia, 119, 44—19
  Eunicites, 229, 91—29
  Madrepora, 119
palmeri, Orbitoides, 45, 12—7, 8
palmulatus, Callistochiton (var. mirabilis), 527, 216—9-14
paludinaeformis, Strobeus, 479, 196—9
panamensis, Miogypsina, 48, 14—5
  Miolepidocyclina, 48, 14—5
panda, Ostrea, 395, 154—3
panderi, Phragmoceras, 561
pandion, Beloitoceras, 557, 228—16-18
  Oncoceras, 557
panicum, Cylindrophyllum, 95, 30—9, 18
pannulus, a, Dictyonina, 287, 108—12-14
  Trematis, 287
papilio, Beyrichona, 657, 278—7
papillata, Cidaris, 219
  Dorocidaris, 219
papulosus, Delocrinus, 171, 65—26
papyracea, Pholadomya, 414, 165—15, 16
  Venus, 425
paquettensis, e, Paleoalveolites, 105, 36—1, 2
  Tripteroceras, 557
paradoxides, Protolenus, 615
paradoxus, Entomilitus (var. pisiformis), 600
  Serpulospira, 465, 188—9
  Straparolus, 465, 188—9
parallelus, a, um, Cavellina, 685, 288—30, 31
  Flustra, 270
  Muensteroceras, 571, 233—19, 20
  Thamnobeatricea, 63
parasiticus, Hemicystites, 131, 49—13
parastatus, Hemiaster, 225, 87—13-16
pariense, Exiteloceras, 593, 246—7-9
parilis, Plaxocrinus, 163, 63—5
  Taras, 423, 168—33
  Tenea, 423, 169—1
parisianus, Columbites, 579, 238—24-26
parkinsoni, Encrinites, 205
  Nautilus, 549
parma, Scutella, 223
parrishi, Lepetopsis, 469, 192—1, 2
parvicella, Leiosoecia, 251, 96—9
  Multicrescis, 251
parvulus, a, um, Bathyurus, 607
  Bonnia, 607, 256—5
  Hexagonaria, 95, 30—13, 14
  Lepidocyclina, 45, 13—7, 8
  Odontopleura, 651, 271—2
  Rhabdocyclus, 85, 23—11-14
parvus, a, um, Aorocrinus, 195, 76—11
  Bakewellia, 389, 150—19
  Billingsaria, 105, 35—16-20
  Climacograptus, 73, 21—38
  Columnaria, 105
  Endelocrinus, 173, 65—1
  Hindia, 53, 16—2-4
  Homocrinus, 145, 52—7; 53—4
  Mangelia, 514, 211—17
  Nuculana, 377, 146—28
  Orthambonites, 355
  Orthonychia, 473, 193—11, 12
parvus, Phragmoceras, 561, 230—6
  Platyceras, 473, 193—11, 12
  Saccella, 377, 146—28
  Schistocrinus, 165, 64—27
  Sphaerexochus, 653, 272—16
patagiata, Requienia, 421, 168—1, 2
  Toucasia, 421, 168—1, 2
patei, Pycnosaccus, 181, 54—4
patelliformis, Anisomyon, 519, 212—28-31
  Helcion, 519
patersoni, Cymostrophia, 339, 129—8, 9
pateus, Geodites, 56, 16—21, 26
patulus, Aatocrinus, 163, 63—4
  Bellerophon, 441
  Didymograptus, 70, 21—13
  Modiolodon, 411, 163—25, 26
  Ptomatis, 441, 177—1-4
patuxentium, Caecum, 491, 200—28
  Micranellium, 491, 200—28
paucidactylus, Ctenocrinus, 200, 74—12
paucifex, Aturoidea, 549, 225—14
paulensis, Laurelocrinus, 200, 73—20
pauperculum, Cardium, 423, 169—5
  Dentalium, 523, 214—7
  Laevidentalium, 523, 214—7
pavilionensis, Pentamerella, 305, 115—16-18
pavonia, Escharopora, 267, 101—25, 26
peckhanis, Pecten, 407, 162—1, 2
pecten, Ctenopyge, 623, 262—22, 23
  Murex, 505
  Olenus, 623
  Sphaerophthalmus, 623
pectinata, Ligonodina, 241, 93—75
pectinella, Dinorthis, 298, 111—47, 48
  Orthis, 297
peculiaris, Actinotrypa, 271, 103—7
  Atrypa, 311
  Costellirostra, 311, 118—44-48
  Fistulipora, 271
pedata, Monoceratina, 693, 292—33, 34
pedernalis, Lunatia, 483, 198—33
pediformis, Bythocypris, 683, 287—54-56
pedroanus, Pecten, 407, 162—1, 2
  Pseudamusium, 407, 162—1, 2
pedunculata, Goniopora, 117
peinei, Micraster, 226
pelagica, Straparollina, 469, 192—12, 13
pelops, Bellerophon, 443, 178—15-17
  Michelinoceras, 537, 219—12
pencillus, Xenocrinus, 189
penelope, Rhipodomella, 355, 139—21-23
penicillus, Linocrinus, 167, 64—20
penita, Ficopsis, 500, 205—17
pennatus, Spirifer, 321
pennsylvanicus, a, um, Diaphelasma, 303, 114—24-28
  Emanuella, 329, 126—38, 39
  Kloedenella, 677, 284—22-24
  Kloedenia, 677
  Venus, 423
pentagonalis, Acanthoscapha, 682, 286—42, 43
pentagonus, a, um, Actinocrinus, 193
  Adinocrinus, 161, 60—24
  Arachnophyllum, 101, 34—2-4
  Steganocrinus, 193, 77—6
pentangularis, Euomphalus, 465
  Stromatocystites, 129
pentanodus, Delocrinus, 163
  Utharocrinus, 163, 62—13; 64—18
peosta, Diplograptus, 73, 22—6, 7
  Orthograptus, 73, 22—6, 7
pepina, Orthis, 293
pepinensis, Dikelocephalus, 633
  Saukia, 633
  Saukiella, 633, 260—31-37
peracutus, a, um, Aviculopinna, 387, 150—8, 9
  Eulima, 477

peracutus, Meekospira, 477, 195—20
Raphistoma, 449, 181—17–20
peramplus, Endolobus, 547
Nautilus, 547
perangulatus, a, um, Goniophora, 413, 164—14
Lophospira, 449, 182—3–5
Loxoplocus, 449, 182—3–5
perannulata, Anisopyge, 637, 275—19–22
Phillipsia, 637
perapiculata, Paracypris, 687, 288—52
perattenuata, Myalina, 393, 153—5
Turritella, 493, 202—12
perattica, Krithe, 691, 291—36, 37
percarinatus, a, um, Bellerophon, 445
Hexagonaria, 95, 30—16–18
Pharkidonotus, 445, 179—24–26
percensis, Marsipograptus, 67, 20—23
percinctum, Centrocyrtoceras, 543, 222—11, 12
percingulatum, Cyclonema, 471, 192—29
percrassa, Nucula, 375, 145—37, 38
perdecora, Loxoconcha, 691
peregrina, Rhynchonella, 315
perelegans, Isorthis, 357, 139—50
Syringopora, 115, 42—10
perfecta, Billingsella, 293, 110—12–17
Hymenocaris, 655, 277—1
perfoliatum, Cyathophyllum, 101
perforata, Fenestella, 263
Loculipora, 263, 99—33
Pontocypris, 683, 288—4, 5
perhumerosa, Baylea, 453, 184—8, 9
perilla, Palaeostrophia, 301
perlamellosa, um, Delthyris, 327, 125—21, 22
Rhynchotrema, 309, 118—29, 30
perlata, Pyropsis, 501
perlobata, Palmatolepis, 245
permiana, Crania, 351
Dithyrocaris, 671
perminuta, Eucochlis, 471, 193—20
permutabile, Bittium, 495, 203—15
pernasuta, Ptychoparia, 623
pernodosus, Euomphalus, 465, 188—20–22
Straparolus, 465, 188—20–22
pero, Ptychoparia, 635
Wilbernia, 635, 266—20–22
perovalis, Prionothyris, 364, 142—16–19
perparva, Earlandia, 13, 1—5
perplanus, a, um, Aequipecten, 407
Pecten, 407
Protoleptostrophia, 341, 131—15–17
Scambula, 419, 167—6, 7
perplexus, a, um, Diabolocrinus, 185, 72—15
Phricodothyris, 329, 126—9, 10
Poteriocrinus, 154
perpusilla, Proporocyclina, 47, 12—16, 17
Pseudophragmina, 47, 12—16, 17
perrini, Glycymeris, 383, 148—11
persa, Orthosurcula, 514, 211—28
perseus, Conaspis, 621, 263—27
Conocephalites, 621
perspectivus, Trochus, 489
pertenuis, Clementia, 425, 170—3
Egesta, 425, 170—3
Phacelopora, 253, 96—4
pertenuistriatus, Camptonectes, 405
Pecten, 405
perundatus, a, Anastomopora, 264, 100—8
Plaxocrinus, 163, 63—9
peruvianus, a, Buxtonia, 350, 136—21
Chiton, 526
pervermiformis, Serpula, 231, 92—12
perversus, a, um, Busycon, 503
Nerita, 479
Schuchertella, 343, 132—43–45
Velates, 480, 197—35–37
petalliformis, Porites, 103
petoskeyense, Streptelasma, 85, 24—4–7
petrolia, Scalez, 487, 199—18, 19
petrosus, a, um, Gyrodes, 483, 198—13–15
Pteria, 391, 152—3, 4
Volutocorbis, 508, 209—3–5
pettiti, Amphicyrtoceras, 559, 229—13, 14
pharetra, Turbinolia, 121, 45—11–13
phaseola, Reniera, 56, 16—29
philanthropus, Calliostoma, 480, 197—2
Psammechinus, 221, 84—11–13
philipi, Edmondia, 373, 145—8
philippii, Atractites, 595, 250—1, 2
phillipsii, Naticopsis, 475
phlyctainoides, Trochurus, 654, 270—1–4
pholadiformis, Ribeiria, 659
phrygia, Zaphrentis, 91, 27—15–17
phycoides, Thallograptus, 67, 20—20
piasaense, Rhineoderma, 455, 183—30, 31
pictus, Ammonites (var. costatus), 583
Delocrinus, 171, 173, 65—12
pierdenalis, e, Ammonites, 593
Engonoceras, 593, 248—1–3
pigmea, Uvigerina, 37
pileus, Agelacrinus, 131
Lepidodiscus, 131
pilula, Pisocrinus, 147
pinguis, Cypraea, 500
Tornatellaea, 515
pinguiscula, Monopleura, 421, 168—8
pinnaeformis, Avicula, 387
pinnaformis, Lingula, 285
Lingulepis, 285, 107—1, 2
pinyonensis, Acrospirifer, 325, 123—14
piochii, Aucella (var. ovata), 395, 153—15, 16
Buchia, 395, 153—12
pirum, Acrocrinus, 199, 78—14
pisiformis, Agnostus, 600
Agnostus (var. obesus), 600
Lecanocrinus, 181, 54—2
Nucleospira, 331, 127—10, 11
pisum, Cryptoblastus, 137, 51—35, 36
placenta, Ammonites, 595
Favosites, 107, 37—11–13
Placenticeras, 595, 249—5
placidus, Athlocrinus, 163, 62—1; 63—13
plaitum, Loxostoma, 37, 8—18
planatus, a, Bolivinita, 33, 8—7
Holectypus, 221, 226, 84—4–9
planiceps, Conus, 513, 211—3, 4
planicosta, Venericardia, 419, 167—22–24
Venericardia (var. claiboplata), 419, 167—22
Venericardia (var. hornii), 419
Venericor, 419, 167—22–24
planicostatus, a, Shansiella, 457, 185—9, 10
Spirifer, 323
planidorsalis, Hesperonomia, 297, 111—16–20
planidorsatus, Euomphalus, 465, 188—13, 14
Straparolus, 465, 188—13, 14
planilateralis, Meekospira, 477, 195—6–8
planimarginata, Nucula, 375, 145—35
planoconvexus, a, um, Agaricocrinus, 195, 76—13
Crurithyris, 329, 126—18–20
Orthis, 355
Planorbis, 519, 213—5, 6
Platyorthis, 355, 139—1–4
Strophomena, 337, 130—1–5
Tripteroceras, 557, 228—12, 13
planodorsatum, Semicoscinium, 263, 99—31
planoradiatus, Aviculopecten, 401
planorbis, Cornuspira, 29
planula, Ammonites, 585
planulatus, a, um, Cleidophorus, 377, 146—17
Helicotoma, 467, 189—9
Nuculites, 377
planumbona, Leptaena, 337
Strophomena, 337, 130—21–24
planus, a, um, Crepidula, 489, 199—40, 41

planus, Crucibulum, 487
Cyathocrinites, 154
Dimerocrinites, 187, 72—7
Eurymya, 411, 164—8, 9
Lyrodesma, 399
Modiolopsis, 411
Nereidavus, 229, 91—49
Paradelocrinus, 173, 65—24
Placenticeras, 595, 249—3, 4
Sphaerium, 419, 167—10
platesea, Camptonectes, 405, 161—4
Pecten, 405, 161—4
plattinensis, Cordylodus, 240, 93—67
platys, Calymene, 641, 272—8–10
Multicostella, 297
plebeia, Periporosella, 271, 103—19
Turritella, 493, 202—4–6
Turritella (var. octonaria), 493, 202—6
plectrum, Buccinum, 503, 207—5
plena, Rostricellula, 309, 117—25–29
plenidens, Arabellites, 229, 91—20
pleromatis, Physa, 519, 213—3
pleurexanthemus, Ceraurus, 641, 272—14
pleurisepta, Sphenodiscus, 595, 248—8, 9
pleuronectes, Ostrea, 405
pleurovimineus, Eucladocrinus, 205, 78—28
plicaria, Voluta, 509
plicatella, Orthis, 299
Plectorthis, 299, 112—40
plicatula, Turbonilla, 481
plicatus, a, um, Bolivina, 35
Camerella, 303, 114—39–43
Choristothyris, 365, 143—35–37
Dichocrinus, 197, 199, 78—5
Spondylus, 407
Terebratula, 365
Turbo, 481
Vexillum, 509
Xenodiscus, 569
pluma, Ptilopora, 265
Retepora, 265
plummerae, Paleochiridota, 227, 90—10
Pseudouvigerina, 35, 8—11
Tritaxia, 18, 2—7
plummeri, Euomphalus, 465, 188—32, 33
Siphogenerina, 35
Siphogenerinoides, 35, 8—12
Straparolus, 465, 188—32, 33
Triticites, 23, 3—1, 2
plumosus, a, um, Cordylocrinus, 203, 77—27
Corematocrinus, 167, 169, 58—7
Coscinium, 270
Ostrea, 395, 154—17, 18
Ptilograptus, 67, 69, 20—22
plumulosus, Inocaulis, 67, 20—9
pocilliformis, Edriocrinus, 205
poinsettiformis, Pterocerella, 499, 204—14
politus, a, um, Arabellites, 229, 91—3
Dicellomus, 285, 107—8–14
Dimorphoceras, 575, 236—3, 4
Fusimitra, 509, 210—1
Lingula, 285
Paracypris, 687
Plaxocrinus, 163, 63—1
polydactylus, Dichocrinus, 199
Eucalyptocrinus, 200
Paradichocrinus, 199, 78—1, 6
polymorphus, Mytilus, 413
polyphemus, Limulus, 707, 300—15–17
Monoculus, 707
polyxo, Botryocrinus, 155, 54—22
pomatia, Helix, 521
ponderosus, a, um, Anolotichia, 253
Brahmacrinus, 200
Exogyra, 233, 397
Nautilus, 547
ponderosus, Nicholsonella, 259
Platystrophia, 299, 113—41–44
Plethomytilus, 387, 150—2, 3
Rafinesquina, 337
Titanoceras, 547, 224—5, 6
porosa, Astraea, 103
porosissima, Cenosphaera, 48, 14—26
portlandicus, Maragnicrinus, 157, 57—12
portlocki, Exochops, 645, 276—7
Phillipsia, 645
portlockianus, Dictyoclostus, 350, 136—7, 8
postica, Paraechmina, 665
potens, Leptodesma, 385
powersi, Archinacella, 469, 191—1, 2
powriei, Stylonurus, 707
praecursor, Neozeacrinus, 167, 63—21
praemarginalis, Plectatrypa, 317, 120—66–68
praemorsus, a, um, Astylospongia, 53, 15—14, 15
Linocrinus, 167, 64—22
Siphonia, 53
praenuntia, Dekayella, 258, 97—28–31
Dekayella (var. echinata), 97—28, 29
Dekayella (var. multipora), 97—30
Dekayella (var. simplex), 97—31
praevalens, Plaxocrinus, 163, 62—5; 63—16
prattenianus, Linoproductus, 351, 137—31
pratti, Massilina, 27, 5—5
Orbitulites, 47
Stomatopora, 250, 95—10
prematurum, Tarphyceras, 541
pretiosa, Protocaris, 655, 277—3, 4
Scalaria, 481
primaevus, a, um, Eocystites, 125, 47—28, 29
Fusulinella, 21, 3—37, 38
Spirifer, 323
primogenius, Strobeus, 479, 196—10, 11
primordialis, Hyolithes, 525, 215—45, 46
Theca, 525, 215—45, 46
primus, a, um, Bisatoceras, 573, 235—3, 4
Cybeloides, 643, 271—23, 24
Dichognathus, 243
Ectodermites, 673, 282—49, 50
Harpes, 645
Oryctocephalus, 615
Phragmodus, 241
Prouddenites, 567, 232—12, 13
Pseudopolygnathus, 244, 94—11, 12
Spathodus, 244
Spathognathodus, 244
Syringospira, 327, 125—12–14
Ulrichodina, 240
princeps, Barycrinus, 154, 57—26
Borelis, 23
Crepidula, 489, 201—20, 21
Hyolithes, 525, 215—16–20
Pseudaviculopecten, 403, 160—3
Pterinopecten, 403, 160—3
princiana, Grammysioidea, 371
priodon, Lomatoceras, 75
priscus, a, um, Arabellites, 229, 91—19
Ectomaria, 459, 186—14
Elliptio (var. priscus), 399, 158—15, 16
Lytospira, 465, 189—1, 2
Monomerella, 287, 107—34–36
Pinna, 387
Unio (var. priscus), 399, 158—15, 16
prisma, Hexagonaria, 95, 30—11, 12
prismatica, Prismodictya, 55, 16—27
pristiniformis, Diplograptus, 73
pristis, Diplograptus, 73, 75
Prionotus, 73
problema, Guttulina, 32, 7—1
problematicus, a, um, Holteria, 611, 259—20, 21
Hybocystites, 151
Ogygia, 611
Pleurodictyum, 111

problematicus, Pterygotus, 709
proboscidea, Entalophora, 251, 95—22
proboscidialis, Actinocrinus, 191
Cactocrinus, 191, 77—3
proclivis, Lytospira, 465, 189—3, 4
productus, a, um, Glossopleura, 611, 258—4, 5
Mya, 431, 173—4–6
Protarabellites, 231, 91—62
Rhytimya, 414, 165—6
profundus, a, um, Archeocyathus, 57
Cambrocyathus, 57, 17—22, 23
Cyathophyllum, 93
Dictyocoryne, 48, 14—22
Lambeophyllum, 93, 29—3–5
Leptaena, 339
Lophophyllum, 87
Pinacodus, 244
Pinacognathus, 244, 94—3
Protomegastrophia, 339, 129—12, 13
Pteronites, 391, 152—12
progne, Liospira, 453, 183—13–15
prolabiata, Aporrhais, 499, 204—9
Perissoptera, 499, 204—9
proliferus, a, um, Acrogenia, 270, 102—19, 20
Cryptozoon, 717, 303—39
Cryptozoon (var. fieldii), 717
Cyathaxonia, 87
Lithostrotion, 89, 26—6–8
Lophophyllidium, 87, 25—1–7
prolificus, a, um, Cedaria, 621, 264—3–7
Coosella, 621, 264—16–21
Favosites, 107
Heterophrentis, 91, 28—7–11
Paleofavosites, 107, 37—17
Zaphrentis, 91
prolixa, Arapahoia, 619, 263—19, 20
prominens, Bailiaspis, 607, 253—16
Berenicea, 250
pronus, Stenopilus, 633, 260—10, 11
propinquum, Harpoceras, 583, 240—13, 14
propleura, Gervillia, 389, 150—21
proprius, Cornulites, 233
prosseri, Amblysiphonella, 56, 17—8, 9
Pecten, 405, 160—14
Pernopecten, 405, 160—14
protea, Orthovertella, 29, 5—11, 12
proteiforme, Endoceras, 533, 217—17–19
protensus, Paradelocrinus, 173, 65—23
protexta, Liopistha, 415, 165—28
protobifidus, Didymograptus, 70, 21—18
protracta, Volutoderma, 509, 209—20
protuberans, Barycrinus, 154, 57—15
proutanus, a, um, Anematina, 471, 192—18, 19
Archimedes, 264
Hemitrypa, 264, 100—1, 2
Holopea, 471
providencesis, Aviculopecten, 401, 159—20
Fasciculiconcha, 401, 159—20
proximus, a, Hipparionyx, 343, 134—6, 7
Pyropsis, 501, 206—10, 11
prunum, Atrypa, 319
pseudo-elegans, Nautilus, 549
pseudogaleata, Gypidula, 305, 115—6, 7
pseudolineatus, a, Spirifer, 327
Torynifera, 327, 126—4–8, 16, 17
pteropsis, Crassatellites, 419, 167—4
pugilis, Strombus, 499
pugiloides, Strombus, 499
pugnax, Orthaulax, 499, 204—16, 17
Orthaulax (var. hernandoensis), 499, 204—16, 17
pulaskiensis, Onychocrinus, 179, 69—3
pulchellus, a, um, Arthroclema, 265
Brassicephalus, 621, 263—21–23
Cavellina, 685, 288—32
Chiton, 527
Gyronema, 451, 182—34
pulchellus, Loricula, 695
Ringicula, 515, 212—3, 4
Salterella, 531, 217—4
Trochonema, 451, 182—34
Urasterella, 213, 81—6, 7
pulcher, Punctospirifer, 361, 141—8
pulchra, Lonchodina, 243, 94—22
Nicholsonella, 259, 98—30
pumilis, Perimestocrinus, 161, 64—4
punctatus, a, um, Anomites, 350
Callopora, 259
Cibolocrinus, 183, 56—13
Comarocystites, 127, 47—24–26
Cremacrinus, 145
Echinocaris, 659, 279—42
Entomostracites, 645
Eodiscus, 611, 252—1
Lepralia, 275
Lingula, 285
Productus, 1, 350
Trilobus, 645
punctifrons, Loxobucania, 445, 179—15
punctipora, Stictotrypa, 271, 103—5, 6
punctobrachiata, Arthroacantha, 197, 78—9
punctocoelatus, a, Rictaxis, 515, 212—12, 13
Tornatella, 515
punctostriata, Barychilina, 687, 288—35–38
Sowerbyella, 335, 128—44–49
punctulatus, a, Anomalina, 43
Cancer, 701
punctulifera, Strophonella, 339, 130—19, 20
punctuosus, Agnostus, 600
Ptychagnostus, 600, 251—20
pupoides, Palaeostylus, 461
purpurata, Oliva, 511
pusillanima, Turbinolia, 121, 45—18, 19
pusillus, um, Clypeoceras, 579, 237—6–8
Lecanocrinus, 181, 54—1
pustulosissima, Cythereis, 688, 289—31, 32
pustullosus, a, um, Brachial, 209
Cidaris, 221
Gnathodus, 245, 94—59–61
Griffithides, 647, 275—10–12
Parulocrinus, 175, 64—31
Pustulina, 319, 121—33–37
Stereobrachicrinus, 209, 79—12
Vitulina, 319
puteatus, um, Kallimorphocrinus, 149, 56—6
Leiostegium, 649, 267—20–22
puteolata, Intrapora, 269, 101—27
putillus, a, um, Climacograptus, 73, 21—39
Gasconadia, 459, 186—9–11
Murchisonia, 459
Nanorthis, 295
puzosianus, Belemnite, 595
pycnopleura, Lyria, 508, 209—1, 2
pygmaeus, a, um, Climacograptus, 73
Girtyspira, 477, 195—11, 12
Modiella, 393, 153—11
Pterinea, 393
pyramidatus, Codaster, 134, 50—4, 5
pyrene, Holopea, 469, 192—5, 6
pyriformis, e, Actinocrinus, 195
Busycon, 501
Corbula, 431, 172—1, 2
Edriocrinus, 205, 79—28
Forbesiocrinus, 179, 68—13
Héliolithe, 103
Nidulites, 57, 17—21
Pentremites, 134, 50—19, 26
Uperocrinus, 195, 197, 76—24
pyruloides, Caricella, 508, 209—8
Turbinella, 508
pyrum, Busycon, 501
Clidochirus, 183
Voluta, 508

python, Deiroceras, 555, 228—1
Orthoceras, 555
pyxidatus, a, Metaplasia, 329, 126—40–43
Spirifer, 329

Q

quadrangularis, Agraulos, 605, 255—13, 14
Cryptothyrella, 331, 126—50, 51
Trigonia, 401, 159—9
Whitfieldella, 331
quadrangulus, um, Tainoceras, 547, 223—14
Nautilus, 547
quadratus, a, um, Bathyurus, 649
Chaetetes, 258
Delocrinus, 173, 65—9
Illaenurus, 627, 260—16–19
Leiostegium, 649, 267—16
Leptochirognathus, 237, 93—11
Palaeanatina, 371
Rhombotrypa, 258, 97—24, 25
quadribrachiatus, Tetragraptus, 70, 21—5
quadricostatus, a, um, Ecphora, 505, 208—3
Ecphora (var. umbilicata), 505, 208—4
Hyolithes, 525, 215—24–26
Orthis, 311
quadrifidus, Aporrhais, 499
quadrilatera, Textularia, 33
quadrilirata, Beyrichia, 667
Tetradella, 667, 281—44, 45
quadrilobatus, Balantoides, 673, 282—48
quadrimucronatus, Glossograptus, 75, 22—12, 13
Glossograptus (var. approximatus), 75
Glossograptus (var. cornutus), 75, 22—18
quadriplicata, Alectryonia, 395, 153—22, 23
Ostrea, 395, 153—22, 23
quadrisualcta, Conularia, 77
quadruplicatus, a, Scolopodus, 240, 93—38, 39
Siphonodella, 245, 94—44, 45
quatuordecimbrachialis, Graphiocrinus, 175
quebecensis, e, Diaphelasma, 303
Mesotrypa, 257, 97—14, 15
Palaeacmaea, 439, 175—11
quercollis, Fulgurofusus, 507, 208—20
Fusus, 507
quillensis, Cyclotella, 301—42
quincuncialis, Lyropora, 264, 100—23, 24
quincyense, Orthonychia, 473, 193—18
Platyceras, 473, 193—18
quinquacutus, Utharocrinus, 163, 62—14; 64—17
quinquefora, Scutella, 223
quinquelobus, Pisocrinus, 147, 54—15
quinquenodus, Platycrinites, 203, 78—19
Pterinocrinus, 187, 72—22
quinquies, Echinodiscus (var. perforata), 223

R

racinensis, Neozaphrentis, 91, 27—21, 22
radialis, Actinopterella, 383, 149—9, 10
Pterinea, 383
radians, Chaetetes, 103
radiatus, a, um, Ambonychia, 385
Ammonites, 587
Byssonychia, 385, 149—23, 24, 27, 28
Carabocrinus, 151, 153, 53—5
Cardiopsis, 371, 145—10
Clinopistha, 369, 144—5, 6
Clinopistha (var. levis), 369
Dichocrinus, 197
Entomaspis, 625, 265—1–3
Eospirifer, 321, 121—47–49
Evactinopora, 270, 271, 102—8–11
Oldhamia, 719
Orthotetes, 343
Pholadella, 414, 165—8, 9
Pycnodonte, 397
Rhytimya, 414, 165—5
radiatus, Spirifer, 319
Tellina, 427
radicans, Clionolithes, 57
Leptalosia, 349, 135—34, 35
radicula, Nautilus, 31
radlerae, Hollinella, 669, 282—7–9
radula, Pleurotomaria, 453
rafinesquii, Leiopteria, 385, 149—4
ramifer, Gazacrinus, 189, 72—10
ramosissimus, Botryocrinus, 155
ramosus, a, um, Amorphognathus, 237, 93—5, 6
Dicranograptus, 71, 21—25
Graptolithus, 71
Hallopora, 261
Lissocoelia, 51, 15—13
ramulosus, a, Inocaulis, 67, 20—10
Syringopora, 115
rana, Phacops, 651, 274—2–5
randalli, Nucula, 375, 145—22
ransomei, Arapahoia, 619, 263—15, 16
rapum, Busycon, 501
raymondi, Leurocycloceras, 539, 220—4
Mcewanella, 301, 112—54–58
raynoldsianus, Viviparus, 487, 199—14
reclusiana, Neverita, 483, 198—5
rectangularis, Sinuites, 441, 176—21–23
recticardinalis, Dielymella, 657, 278—13
rectidens, Arabellites, 229, 91—12, 13
rectiforcatum, Tremotoichos, 275, 104—14
rectifrons, Isotelus, 639
rectilamellosa, Thamnasteria, 117, 42—20
rectilaterarius, Dunbarella, 403, 160—4, 5
Pterinopecten, 403, 160—4, 5
rectirostra, Cryptonella, 364, 142—23–26
Terebratula, 364
rectistriatus, Lophospira, 449, 182—6, 7
Loxoplocus, 449, 182—6, 7
rectus, a, um, Escharopora, 267
Orthodesma, 369, 144—11
Stereolasma, 87, 24—17–22
Streptelasma, 87
Strombodes, 87
Tabulophyllum, 95, 97, 31—1–4
Volsella, 413, 164—15
recurvirostris, Myalina, 393, 153—9
Zygospira, 317, 120—56
recurvus, a, um, Cimitaria, 414, 165—17, 18
Cypricardites, 414
Hypseloconus, 439, 175—14, 15
Hypseloconus (var. elongatus), 439
redmondianum, Flabellum, 122, 46—6, 7
reedsi, Amphiscapha, 465, 188—26–28
Euomphalus, 465
Straparolus, 465, 188—26–28
reesidei, Spondylospira, 359, 140—43–47
reevii, Lingula, 285, 107—20
refulgens, Cibicides, 43
regalis, Actinocrinus, 193
Sinuopea, 447, 180—9
regularia, Kirkbya, 671, 282—19
regularis, Ammodiscus, 15, 1—9
Apical, 209, 79—25
Bollia, 667, 281—27, 28
Derbyia, 345
Floridina, 273, 103—23
Orthoceratites, 537
Ozarkodina, 244, 94—17
Poteriocrinus, 159
Spathognathodus, 244, 94—1
Strobeus, 479, 196—12
Subulites, 477, 195—27
regulosus, Agnostus, 600, 251—13, 14
reidi, Clavator, 713
reinwardti, Pentremites, 135
Troosticrinus, 135, 51—2
remibrachiatus, Eretmocrinus, 195, 76—20

remipes, Eurypterus, 707, 299—1, 2
remnicha, Eoorthis, 295, 110—29–33
Orthis, 295
remondi, Ficopsis, 500, 205—15, 16
remondii, Hemifusus, 500
remotiseptum, Deiroceras, 555, 228—2
reniformis, Bythocypris, 683
rensselaericus, Archeocyathus, 56, 17—14, 15
repandus, Nautilus, 39
repens, Vinella, 250, 95—4, 5
repertus, Decadocrinus, 169, 65—26
resseri, Dolichometopsis, 609
resupinatus, Anomites, 357
Conchyliolithus, 357
reticularis, Anomia, 317
Atrypa, 1, 319, 121—1-3, 14, 15
reticulatus, a, um, Ammonites, 581
Dictyonella, 307, 117—22-24
Eurychilina, 673, 283—20
Intricaria, 261
Lima, 409, 163—13
Murex, 495
Rhynchonella, 307
Scenella, 437, 175—3
Strombiformis, 495
Subretepora, 261, 99—21
Sycidium, 713
Tellina, 429
Tretaspis, 654, 267—39-41
Tryblidium, 437
Voluta, 514
reticulosus, a, Coleites, 39, 10—1, 2
Pulvinulina, 39
retifera, Halliella, 665, 281—14
Lima, 409, 163—10
Tuzoia, 655, 278—15, 16
retiformis, e, Dictyonema, 65, 20—12
Gorgonia, 65
Syringopora, 115, 41—20
retrorsus, Cyrtolites, 439, 175—26, 27
retrostriata, Buchiola, 373
retusa, Anomia, 365
reussiana, Bairdia, 683, 287—31-34
Goniopora, 117, 43—16, 17
reversata, Platystrophia, 299, 113—26, 27
reversus, a, um, Chonetes, 347
Pterinea, 403
Strophodonta, 339
Strophonelloides, 339, 131—7-11
Vertumnia, 403, 160—2
rex, Battus, 600
Condylopyge, 600, 251—23, 24; 276—17, 18
Leperditella, 664, 280—31
reynoldsi, Oryctocephalus, 615, 257—23
rhinoceras, Amphilichas, 649
Kerakephalichas, 649, 270—5
rhombicus, Coeloconus, 267
rhomboidalis, Conchita, 341
Leptaena, 1, 343, 132—16-22
rhomboidea, um, Fasciolaria, 507, 208—8
Semicoscinium, 263
rhotomagensis, Ammonites, 591
richardsoni, Ammonites, 585
Caneyella, 391, 152—13, 14
Eopteria, 659, 297—7, 8
Zemistephanus, 585, 241—15-17
richmondensis, e, Aechmina, 665, 280—51, 52
Leptaena, 343, 132—23-25
Salpingostoma, 443, 177—17, 18
richteri, Orthoceras, 555
richthofeni, Leptodus, 345
ridleyana, Protorhyncha, 307, 117—30-33
rigidus, Pecten, 407, 161—15, 16
rimulata, Periporosella, 271, 103—20
riovistae, Hemiaster, 226
Washitaster, 226, 88—8
ripleyensis, Lamarckina, 37, 9—2
Textularia, 17, 2—2
rivale, Orthoceras, 537
robertsensis, Meristella, 333, 127—23-25
robsonensis, Bynumia, 621, 263—32, 33
robustus, a, um, Aatocrinus, 163, 62—21; 63—11
Bradoria, 655, 278—1
Coosia, 623, 264—26
Cyathophyllum, 95, 29—20, 21
Donaldina, 463, 187—27-29
Kellettina, 673, 283—11
Metracolposa, 275, 104—7
Pachydictya, 269
Palliseria, 469, 191—20
Perprimitia, 665, 281—20
Protaxocrinus, 177, 54—13
Scaphiocrinus, 169
Synbathocrinus, 151, 55—11; 56—23
Ulrichia, 673
Zeacrinus, 163
rockfordensis, Nervostrophia, 341, 131—24, 25
rockymontanus, um, Leiorhynchus, 313, 119—17-19
Spirifer, 325, 124—20-22
roddyi, Eoagnostus, 600, 251—15
roemeri, Cryptoblastus, 137, 51—29-31
Dikelocephalus, 625
Elvinia, 625, 264—34-37
Eospongia, 51, 53, 15—4
Lampterocrinus, 187, 72—17
Neithea, 405, 161—6
Pecten, 405, 161—6
Sieberella, 305, 115—12, 13
roemeriana, Montastrea, 119, 44—5, 6
rogata, Resserella, 353, 138—6, 7
rogersi, Clypeaster, 221, 84—14-16
Leptodesma, 385, 149—13
rogersii, Aulacodiscus, 301—40
roissyanus, Ammonites, 589
romboideus, Distacodus, 239
Machairodus, 239
romingeri, Cranaena, 364, 142—30, 31
Gypidula, 305, 115—8, 9
Sphaerexochus, 653, 272—17-22
Terebratula, 364
Zacanthoides, 619, 257—24, 25
rooki, Asterorbis, 45, 12—1, 2
Lepidorbitoides, 45, 12—1, 2
rosaceus, Clypeaster, 221
Echinus, 221
Eucalyptocrinites, 201
rosaeformis, Marsupiocrinus, 201, 77—25
rossae, Monoceratina, 693, 292—41
rossensis, Bathyuriscus, 617
Ptarmigania, 617, 258—6-8
Wimanella, 295, 110—18-21
rostellata, Nuculana, 377, 146—29
rostratus, a, um, Ampyx, 649
Anchura, 497, 203—23
Arca, 377
Bullopora, 32
Oenonites, 229, 91—71
Pteronites, 391, 152—11
Rostricellula, 307, 309, 117—34-40
rota, Nebrodites, 587, 242—18-20
rotalis, Trepospira, 453, 183—16-18
rotatilis, Micrabacia, 117, 43—11-13
rotatorius, Goniatites, 573
rothi, Eoptychia, 461, 186—27
Parafusulina, 27, 4—10-12
Stacheoceras, 577, 236—23
rotulata, Lenticulina, 31
rotuloides, Porpites, 83, 23—4, 5
rotulus, a, Anomphalus, 471, 193—25, 26
Cottaldia, 226, 88—2-4
rotundatus, Bathyuriscus, 607, 258—12
rotundus, a, um, Allocatillocrinus, 149, 56—19

rotundus, Bythocypris, 683, 287—62, 63
Dizygocrinus, 197, 75—2
Holopea, 469, 192—7
Paragazacrinus, 185, 72—25
roundyi, Amphissites, 671, 282—37–39
rowei, Holmia, 611
rowi, Proetus, 653, 274—10
rowleyi, Hybochilocrinus, 147, 56—1
royssyii, Athyris, 333
rubeyi, Helicoceras, 593, 246—11
rubignosa, Anomalina, 43, 11—10
rubra, Actinocrinites, 193, 76—2
Cytheretta, 688
Gypsina, 43, 10—11
rubropicta, Semele, 429, 171—8
rudis, e, Axophyllum, 89, 25—20–22
Bonnemaia, 677, 284—13, 14
Pinna, 387
Straparolus, 465, 188—1
Teleiocrinus, 193, 77—11
ruedemanni, Metaspyroceras, 541, 220—11, 12
Spyroceras, 541
rugatus, Volutocorbis, 508, 209—6
rugosus, a, um, Amphissites, 671, 282—26, 27
Camarocladia, 56
Cyathocrinites, 153
Cyathophyllum, 95
Cyrtodonta, 379
Entelophyllum, 99, 32—14–16
Eridophyllum, 99
Guadryina, 18
Hallopora, 261, 99—5
Macrodon, 379
Macronotella, 665, 280—41
Metoptoma, 439, 175—5–10
Mytilus, 431
Palasterina, 211
Palmatolepis, 245, 94—39
Palmula, 32, 6—14
Patelliocrinus, 200, 73—22
Sagrina, 18
Salterella, 531, 217—2
Saxicava, 431
Sowerbyella, 335, 128—41–43
Stenotheca, 701, 297—9–14
Striatopora, 111
Stromatocerium, 63, 19—12, 13
Sycotypus, 503, 206—22, 23
rugulata, Euryzone, 453, 183—28
russelli, Brachycythere, 688, 289—23–27
Ceratites, 579, 238—15–17
Gymnotoceras, 579, 238—15–17
russiense, Gastrioceras, 573
rusti, Conotreta, 289, 109—1–3
rusticellus, Ascetocrinus, 159, 55—14
Scaphiocrinus, 159
rusticus, um, Pentremites, 134
Streptelasma, 85, 24—8–10
ruthveni, Uraster, 211
rutila, Pseudopolymorphina, 32, 7—3
ruzencevi, Eoasianites, 573, 235—18, 19

S

sabinensis, Cytheridea, 689, 290—5–8
Haplocytheridea, 689, 290—5–8
sacculus, Edriocrinus, 205, 79—27
saffordi, Forbesiocrinus, 179, 68—21
Multicostella, 297, 111—27–31
Norwoodella, 629, 266—4
Norwoodia, 629
Orthis, 297
Platycrinites, 205, 78—27
Pterotheca, 445, 180—17, 18
Trigonarca, 379
Uncinulus, 313, 119—31–34
Volsella, 413, 164—18
sagenella, Glyptopora, 270, 102—18
sagensis, Inoceramus, 389, 151—12
sagenum, Buccinum, 501
sagitta, Beyrichia, 675, 283—29–31
sagittaria, Palmula, 32
sagitticaulis, Didymograptus, 70, 21—15
sagittula, Textularia, 17
sagra, Cancris, 39, 10—8
salamanca, Ptychopteria, 391, 152—22
salinaria, Monotis, 393
salinarum, Halobia, 393
salinensis, Oxytoma, 391, 152—8
Pteria, 391, 152—8
salisburyi, Pullenia, 41, 10—13
salteri, Eunema, 475
Orthonema, 475, 195—1
Stenaster, 211, 81—1
sampsoni, Phillipsia, 651, 276—1–3
sanctaecrucis, Amphiura, 213, 81—17, 18
sancti-ludovici, Fenestralia, 264, 100—25
sanctisabae, Pterocephalia, 631, 266—35–37
sandalinum, Anomia, 99
sandlingensis, Ammonites, 581
Discotropites, 581, 239—4–6
sangamonensis, e, Ameura, 637, 275—25–27
Discus, 547
Metacoceras, 547, 224—3, 4
Nautilus, 547
Phillipsia, 637
Ulocrinus, 175, 56—28
sansabensis, Hypselocrinus, 169, 60—10
sapidus, Callinectes, 699, 295—17–19
sappho, Camarotoechia, 311, 118—57–61
saratogaensis, Agraulos, 631
Billingsia, 439
Flabellammina, 15, 1—13
Matherella, 439, 175—20
Plethopeltis, 631, 260—1–3
sarlei, Lepidocoleus, 695, 293—32–35
sauridens, Conus, 513, 211—1, 2
Lithoconus, 513, 211—1, 2
savagei, Straparolus, 465, 188—16, 17
savartii, Acanthodesia, 273, 103—18
Acanthodesia (var. bifoliata), 273, 103—18
Flustra, 273
sayana, um, Epitonium, 481, 197—28
Oliva, 511, 210—11
sayi, Pentremites, 135
Schizoblastus, 137, 51—17–23
saylesi, Clitendoceras, 535, 218—10
sayrei, Trachydomia, 475, 194—25, 26
scabiosa, Petrocrania, 291, 109—31
scabra, Acanthopleura, 527
Paranomia, 409, 163—20, 21
Placuna, 409
scabricosta, Punctospirifer, 359
scabriculus, Anomites, 350
scabrida, Valvata, 487, 199—29–31
scalariformis, Scalaripora, 270, 102—11
Tentaculites, 526, 214—45, 46
scalaris, Leperditia, 664, 280—5–8
Poteriocrinus, 169
Scaphiocrinus, 169
Tentaculites, 526
Turbo, 481
Unitrypa, 263, 99—35–37
scalpta, Streptacis, 463, 187—20, 21
scamnata, Poleumita, 475, 194—14
scaphoptera, Rhinocaris, 659, 279—34
scarabaeoides, Entomostracites, 629
Peltura, 629, 262—16, 17; 276—24
sceptrum, Dictyophyton, 55
Dictyospongia, 55, 16—36
scharenbergi, Climacograptus, 73, 21—37
schenckii, Acicularia, 302—11–13
schizea, Verneuilina, 18, 2—8

schlotheimi, Schizodus, 401
Terebratula, 315
schlumbergeri, Cornuspira, 29
schmidelianus, Velates, 479
schucherti, Eodiscus, 611
Lingulasma, 285, 107—25-28
Metalegoceras, 573, 235—22, 23
Orthonema, 477, 195—5
Palaeosmilia, 97, 31—12-14
Pseudozygopleura, 461, 187—9
Uddenites, 567, 232—3, 4
scintilla, Leptalosia, 349, 135—41
Naticopsis, 475, 194—22, 23
Strophalosia, 349
scitulus, a, um, Chonetes, 345, 134—11
Cylichna, 517, 212—19, 20
Ditomopyge, 645, 275—4-6
Pseudozygopleura, 461, 187—6, 7
Yoldia, 379, 146—42
scobina, Linocrinus, 167, 64—24
scofieldi, Macronotella, 665, 280—42-44
Whitella, 381, 147—6, 20
scoparius, Ascetocrinus, 159, 55—17
Homocrinus, 158
Lasiocrinus, 158, 52—5; 53—15
scopulosum, Sinum, 481, 198—3
scorpiurus, Reophax, 13
scoticus, a, um, Amphicrinus, 179
Bronteopsis, 639
Fardenia, 343
Tabulipora, 259
scotti, Pirasocrinus, 165, 62—18; 63—23
scottianus, Platycyathus, 121, 44—14-16
Trochocyathus, 121, 44—14-16
scrinium, Mandaloceras, 559, 229—10, 11
scriptus, Murex, 500
scrobiculatus, Cyathocrinites, 181
scrobiculus, Dichostreblocrinus, 154, 56—7
scrutator, Bradoria, 655, 278—2-4
Nileus, 649, 267—34, 35
sculptilis, e, Goniocrinus, 158, 57—7
Iphidea, 287
Metacoceras, 547
Micromitra, 287, 108—1-3
Primitia, 665
Pseudometacoceras, 547, 224—7, 8
sculptus, Hylodecrinus, 161, 60—2
Platycrinites, 203, 78—25
Rhaphanocrinus, 183, 72—23
Steganocrinus, 193, 77—5
Vasocrinus, 154, 57—3
scutella, Tetrataxis, 31, 5—20
scutellatus, Arabellites, 229, 91—4
scutiger, Cidarites, 219
scutulata, Littorina, 489, 200—8-10
secalicus, Miliolites, 23
Triticites, 23, 3—9, 10
secalina, Cylichna, 517, 212—25, 26
secans, Quinqueloculina, 27
secoclefta, Thlipsurella, 682, 286—17, 18
sectifrons, Cypricardites, 369
Phthonia, 369, 144—3
securis, Chione, 427, 170—10; 172—19
Venus, 427, 170—10; 172—19
sedgwicki, Dichograpsus, 69
seelyi, Centrotarphyceras, 541, 221—8
Lituites, 541
Tarphyceras, 543
selenourus, Asaphus, 649
sellaeformis, Ostrea, 395, 154—23
sellardsi, Parafusulina, 27, 4—7-9
Zeacrinites, 165, 63—17
semele, Menomonia, 627, 265—37, 38
semicircularis, e, Buxtonia, 350, 136—20
Triceratium, 301—35
semiconstrictus, Ammodiscus (var. regularis), 15, 1—9
semicostatus, a, Pseudozygopleura, 461, 187—1, 2
Scolopodus, 240, 93—27
semifasciata, Strophonella, 339
semifloralis, Leptochirognathus, 237, 93—13
semiglobata, Reuschella, 355
semilunata, Natica, 485, 199—4
seminulum, Serpula, 27
semiplicatus, a, um, Cythereis, 688, 289—33
Entolium, 495, 161—3
Pecten, 495, 161—3
semipunctatus, Echinoconchus, 350, 137—13-15
semireticulatus, Anomites, 349
semistriatum, Lunulacardium, 385
senaria, Flexicalymene, 645, 272—3-5
senectus, a, Bonnia, 607, 256—11, 12
Unio, 399, 158—19
separata, Lonchodina, 243, 94—23
Trichognathus, 243, 93—72
sepioidea, Beloptera, 597
septarugosum, Duplophyllum, 87, 24—21-24
septata, Öpikina, 337, 129—14-16
septem-notatus, Protichnites, 719
serapio, Idahoia, 625, 265—20, 21
seratim-granulata, Mesalia, 495, 203—3, 4
seriale, Eridophyllum, 89, 27—1-5
seriata, Coenites, 111, 39—11, 12
Plethobolbina, 665, 280—56, 57
serica, Crenella, 413, 164—22-24
sericea, Leptaena, 335
serotina, Fusulinella, 21, 3—35, 36
serpens, Aulopora, 111
serpularius, Cornulites, 233
serra, Fucoides, 69
serrata, Deloia, 679, 285—16-19
Ehrenbergina, 41
serratostriata, Entomis, 687, 289—7, 8
Richteria, 687, 289—7, 8
serratulus, Didymograptus, 70, 21—12
serratus, a, um, Eratocrinus, 167, 60—11
Gyroceras, 547
Oenonites, 231, 91—52
Olenoides, 613, 256—1
serrulatus, a, um, Lophospira, 449, 182—12, 13
Loxoplocus, 449, 182—12, 13
Pontocypris, 683
seticornis, Asaphus, 654
setigerus, a, um, Productus, 350
Setigerites, 350, 136—23-25
Torynifera, 327, 126—13-15
setum, Schwagerina, 25, 4—13-15
sevillensis, Sevillia, 653, 276—14-16
sexcarinata, Tetranota, 441, 177—9-11
sexsulcatus, Anisomyon, 519, 212—35, 36
sextans, Dicellograptus, 71, 21—21
shafferi, Arthropora, 269
Mesopalaeaster, 211, 80—7, 8
Palaeaster, 211
Ptilodictya, 269
Stictopora, 269
shaleri, Eurymyella, 411, 164—7
Hyolithes, 525, 215—31-33
shastaensis, Arcestes, 581, 239—7, 8
Proarcestes, 581, 239—7, 8
shastense, Protrachyceras, 579, 238—21-23
Trachyceras, 579, 238—21-23
shawangunk, Hughmilleria, 709, 299—5, 6
shoshonense, Mortoniceras, 593, 247—9-16
Unio, 399, 158—12
shrocki, Atrypella, 319, 120—62, 63
shumardi, Acila, 375, 146—10
Acrocrinus, 199
Amplexus, 93, 29—6-8
Conocephalites, 633
Elvinia, 625, 264—41, 42
Polypora, 264, 100—9, 10
Teanicephalus, 633, 266—17

shumardi, Truncacila, 375, 146—10
Turbo, 473
Turbonopsis, 473, 194—1, 2
shumardianus, a, um, Chonetes, 345, 134—28, 29
Echinocrinus, 217, 83—6
Heterelasma, 364
Polinices, 483, 198—25
sieberi, Pentamerus, 305
sigillariae, Xylobius, 701, 294—18-20
sigmoidalis, Euglyphella, 681, 286—7
Euglyphella (var. primitiva), 681
Strepula, 681
siliqua, Reniera, 56, 16—28
sillimani, Epitonium, 481, 197—26, 27
siluricus, Parisocrinus, 154, 55—13
Polygnathoides, 245, 94—48, 49
siluriense, Cystiphyllum, 99
simcoense, Synaptophyllum, 95, 30—1-4
similare, Naticonema, 475
similis, Arabellites, 229, 91—9
Arabellites (var. arcuatus), 229, 91—10
Euomphalus, 465, 188—10-12
Hyolithes, 525, 215—21-23
Iddingsia, 627, 265—15, 16
Lingulella, 285, 107—3-5
Ptychoparia, 627
Stictotrypa, 271
Straparolus, 465, 188—10-12
Tetragraptus, 70, 21—6
Ulrichospira, 451
simondsi, Shumardites, 575, 236—16-19
simplex, Actinocrinites, 193
Arthropora, 269, 101—30, 31
Bactropora, 267, 101—18, 19
Coleodus, 237, 93—22
Condracypris, 685, 288—25-27
Cyrtoceras, 557
Ectenocrinus, 145, 52—7; 53—8
Eunicites, 229, 91—22
Hastula, 513, 210—28, 29
Healdia, 682, 287—11
Heterocrinus, 145
Heterophrentis, 91, 28—12
Holaster, 225, 226, 86—19-21; 89—10-12
Kormagnostus, 600, 251—25-27
Leptoptygma, 479, 196—17, 18
Richardsonoceras, 557, 228—19, 20
Vertumnia, 403, 160—1
Wimanella, 293, 110—26-28
simplicius, Pecten, 405, 161—11, 12
simpsoni, Inoceramus, 389, 151—5
simulans, Crepipora, 253, 96—17
simulator, Goniatites, 565
Manticoceras, 565, 231—6-8
simulatrix, Oxoplecia, 307
Prasopora, 257, 97—18, 19
simus, Brachial, 209, 79—11
sinclairensis, Briscoia, 621, 262—29-31
Platycolpus, 629, 260—22, 23
singleyi, Acrohelia, 121, 44—8, 9
sinuatus, a, um, Crassatella, 419
Eukloedenella, 677, 284—9, 10
Hebertella, 299, 113—14-20
Orthis, 299
Surculites, 514, 211—13-15
sinuosus, a, um, Bairdia, 683, 287—35, 36
Centrognathodus, 240, 93—48
Centrognathus, 240
Manticoceras, 565, 231—16, 17
Terebra, 461
sinupyga, Clavaspidella, 609
skidegatensis, Cylindroteuthis, 595, 250—3-5
skinneri, Xenaspis, 569, 233—11, 12
slackiana, Nucula, 375, 145—28, 29
slocumi, Hemiaster, 225, 87—10-12
Heteralosia, 349, 135—36, 37
smithi, Lucina, 423, 168—24
Venericardia, 419, 167—15
Venericor, 419, 167—15
sobolewskyanus, Goniatites, 577
socialis, e, Botryllopora, 255, 96—25, 26
Ctenodonta, 375, 146—6, 7
Dalmania, 643
Echinocaris, 659, 279—32, 39
Hughmilleria, 709, 299—11
Michelinoceras, 537, 219—4-6
Orbitolites, 45
Uintacrinus, 207, 79—31
sohni, Seminolites, 683, 287—7, 8
solarioides, Pycnomphalus, 471, 193—21-23
soledadensis, Tellina, 429, 170—23
soleniscus, Ostrea, 395, 153—19
solenoides, Ceratiocaris, 657
Gervillia, 389
solidiforme, Rayonnoceras, 555, 228—5
solidus, Atractites, 595, 249—13
solitaris, Talbotina, 633, 266—32
solitarius, Nereidavus, 229, 91—50
solutus, a, um, Lophospira, 451, 182—25-27
Loxoplocus, 451, 182—25-27
Murchisonia, 449
Truncatulina, 39
somersi, Delocrinus, 171, 65—15
spadicea, Cypraea, 500, 205—4
spartarius, Blothrocrinus, 158, 58—4
Eupachycrinus, 175, 64—28
spaskii, Cyclocrinites, 719
spatiosus, a, Astrodaspis, 223, 85—8, 9
Zaphrentis, 91
spatulata, Lingula, 285
speciosus, a, um, Buchiola, 373, 145—17, 18
Cardium, 423, 169—6
Dolatocrinus, 201, 74—16
Eodiscus, 611, 252—4-6
Plethorhyncha, 311, 118—71-74
Promopalaeaster, 211
Rhynchonella, 311
Saccocrinus, 191
Trochurus, 654
Worthenia, 457, 185—5-7
spectabilis, Endolobus, 547, 223—13
Nautilus, 547
Planorbis (var. spectabilis), 519
Planorbis (var. utahensis), 519, 213—11-13
specula, Dictyocha, 11
speluncaria, Gryphites, 393
spencei, Nisusia, 293
spergenensis, Straparolus, 465, 188—6-8
sphaera, Biloculina, 29
Echinus, 89—45
Pyrgoella, 29, 5—7, 8
sphaeralis, Ethelocrinus, 175, 65—30
sphaericus, a, um, Conchyliolithus, 571
Fusulina, 21
Nautilus, 571
sphaeroides, Nonionina, 41
sphaeroideus, Haplocrinites, 147
sphaerulata, Pleurotomaria, 453
Trepospira, 453, 183—19, 20
sphenoides, Brachycythere, 688, 289—16-18
Cythere, 688
sphericus, Pisocrinus, 147, 54—16
spicatus, Columnal, 209, 79—20
Neocoleodus, 237, 93—20
spillmani, Cardium, 425, 169—11
spinifer, Aglaspis, 705, 298—2, 3, 7
Dicranograptus, 71, 21—33
Platycrinites (var. elongatus), 203, 78—23
spiniformis, Helopora, 265, 100—28-30
spiniger, Bathyurus, 639, 267—36
Calvinella, 621, 261—13, 14
Dikelocephalus, 621

spinigerus, a, Gilbertsocrinus, 187, 73—5
Strobilepis, 695, 293—9–12
spinosissima, Ehrenbergina, 41, 10—7
spinosus, a, um, Acanthocrinus, 185, 72—13
Aechmina, 665
Ancyrocrinus, 209, 79—30
Atrypa, 319, 121—4, 5
Brachymetopus, 639, 275—16–18
Conus, 508
Crucibulum, 489, 199—39
Culicocrinus, 203, 77—20
Glyptopleura, 681, 285—52
Hydreionocrinus, 167
Olenoides, 619
Palaeocoma, 213
Paraechmina, 665, 280—49, 50
Reticulariina, 361, 141—9–13
Spirifer, 361
Taeniaster, 213, 81—8
Tholocrinus, 167, 59—2
Worthenopora, 271, 103—15, 16
spinulata, Coenites, 111, 39—9, 10
spinulicosta, Productella, 347, 135—29, 30
spinulifer, Decadocrinus, 169, 60—12
spinulosus, a, um, Actinocrinites, 193, 77—13
Batostomella, 258, 98—1–3
Entomostracites, 629
Parabolina, 629, 263—12–14
Promopalaeaster, 211
Triplophyllum, 93, 28—16, 17
Wachsmuthicrinus, 181, 68—8
spiralis, Goniatites, 571
spirata, Natica, 481
Vermicularia, 491, 201—4
spiriferoides, Athyris, 333, 127—39–43
spironema, Gosseletina, 453, 183—33
spirorbis, Serpula, 231
spirulaea, Serpula, 233
spitiensis, Ammonites, 589
splendens, Arthroacantha, 197, 78—10
Cidaris, 219, 83—12, 13
Gaurocrinus, 187
Marginifera, 351, 137—19
Ptychocrinus, 187, 72—19
spongioides, Solenopora, 717
spongites, Eschara, 275
Stylopoma, 275, 104—8
springeri, Cryptoceras, 549
Nautilus, 549
Thamnocrinus, 191, 73—17
spurius, Cyathocrinus, 154
squamiformis, Craniops, 293
Orbicula, 293
squammosus, Virgulina, 35
squamosus, a, um, Agelacrinites, 131
Alveolites, 105
Hamulus, 233, 92—25
Lepidodiscus, 131, 49—21
Pleurocystites, 128, 48—4, 16
stamineus, a, um, Ancillaria, 511
Conomitra, 509, 210—4
Olivula, 511, 210—16
Olivula (var. punctulifera), 511
Raphistoma, 449, 181—21–23
stantoni, Macluritella, 469, 190—15, 16
Nerinella, 495, 203—9–11
Rapana, 505
Sargana, 505, 207—8, 9
staufferi, Callograptus, 65, 20—4, 5
stellaris, Reteocrinus, 183
stellatus, a, um, Agelacrinus, 129
Ascodictyon, 250, 95—2
Cincinnatidiscus, 129, 49—17, 18
Favistella, 97, 99, 32—6, 7
Fenestrellina, 263, 99—28
Gazacrinus, 189, 72—9
stellatus, Glyphodiscus, 301—16
Hemicystites, 129
stelliformis, Orophocrinus, 134, 50—8, 9
Pentremites, 134
stemmatus, Dalmanites, 653
Synphoria, 653, 273—1, 2
stephani, Leptaena, 339
stephensis, Tonkinella, 619, 259—27, 28
stephensoni, Acanthoceras, 591, 245—3, 4
stevensana, Donaldina, 463, 187—25, 26
stevensi, Galateacrinus, 165, 62—2; 64—15
stevensoni, Orthorhynchula, 309
stewartvillensis, Dosiniopsis, 427, 170—16
stigmata, Octonaria, 682, 286—23–25
stillativus, Cyathocrinus, 157, 52—14
Stellarocrinus, 157, 57—13
stimpsoni, Acanthotelson, 697, 294—1–6
stissingensis, Olenoides, 617
stokesi, Platytrochus, 121, 45—20, 21
Ptychophyllum, 97, 31—15–17; 32—19, 20
Turbinolia, 121
stolonifera, Reptaria, 251, 95—20, 21
stramineum, Dentalium, 523, 214—5, 6
streeruwitzi, Tetragamma, 226, 88—5–7
strenuelliformis, Proliostracus, 615
strenuus, a, Agraulos, 617
Strenuella, 617, 253—18
striatellum, Clathrodictyon, 59, 61, 18—17, 18
striaticostatum, Paryphorhynchus, 311, 119—1–3
striatissimus, Marsupiocrinus, 201, 77—24
striatocostata, Meekella, 345, 133—9–16
Plicatula, 345
striatomarginata, Coelochilina, 673, 283—16
striatus, a, um, Anomites, 325
Arachnophyllum, 101, 34—1
Bullia, 517
Dichocrinus, 197, 78—3
Goniatites, 573
Lithostrotion, 89
Maclurea, 449
Macrostylocrinus, 200, 74—5
Molopophorus, 517, 212—27
Palaeocrinus, 151, 53—19
Pallium, 403
Primitiopsis, 681
Ptilopora, 265, 100—21
Ptychaspis, 631, 262—2
Raphistoma, 449, 181—21–23
Tryblidium, 437, 174—3
Venula, 681, 286—10, 11
strictus, a, um, Climacograptus, 73
Enterolasma, 85, 24—14–16
Patraia, 85
Streptelasma, 85
strigata, Yoldia, 379, 146—37
strigilatum, Buccinum, 511
strigilecula, Ostrea, 395, 153—17, 18
strigillatum, Eunema, 451, 182—31
Trochonema, 451, 182—31
strimplei, Allagecrinus, 149, 56—8
striolata, Mangelia, 514
strophomenoides, Orthis, 301
Orthostrophia, 301, 113—38–40
Plaesiomys, 297
Valcourea, 297, 111—21–24
strzeleckii, Brachymetopus, 639
stultorum, Cardium, 431
styloporum, Pleurodictyum, 111, 39—22–24
subaculeatus, Productus, 347
subacutus, a, Asterigerina, 39, 10—5
Tropidodiscus, 443, 178—8, 9
subaequalis, Batocrinus, 195, 75—5
Paltodus, 240
subaequata, Bollia, 667, 281—24–26
Bythocypris, 683, 287—50–53
Orthis, 357

subaequata, Pionodema, 357, 139—46–49
subangularis, Ichythyocrinus, 183, 54—5
Pentacrinus (var. alaska), 207, 79—8
subannulata, um, Centrocyrtoceras, 543, 222—3
Turritella, 493, 202—10
subaraucana, Discorbis, 37, 9—1
subarcuatum, Dentalium, 523, 214—1–4
subbrevis, Fusispira, 477, 195—18
Subulites, 477, 195—18
subbullatus, Ammonites, 579
Tropites, 581, 239—1, 2
subcardiformis, Brachythyris, 327, 125—9–11
subcarinata, Fascifera, 357, 139—35–39
Levenea, 353, 138—21–23
Orthis, 353
subcircularis, e, Monotis, 393, 152—29
Neoglyphioceras, 571, 234—6–8
subcompressa, Corbula, 431, 172—12
Pleuromya, 413, 164—31, 32
subconicus, a, um, Acrotreta, 289
Bactrites, 565
Clathrospira, 455, 184—34
Meekospira, 477, 195—10
Pleurotomaria, 455
subconstricta, Baylea, 453, 184—1–5
subcoronatus, Conocephalites, 605
subcostatus, Pleurophorus, 415, 165—33
Strobeus, 479, 196—8
subcrassus, a, Iocrinus, 143, 53—10, 11
Lunatia, 485, 198—26, 27
subcuneata, Allorisma, 414, 165—10, 11
subcurvata, Prioniodina, 244, 94—24
subcylindrica, Labechia, 63, 19—14, 15
subdeltoidea, Bairdia, 683, 287—37
subdentatus, Multioistodus, 237, 93—10, 19
subelliptica, Cypricardella, 415
subelongatus, Subulites, 477, 195—26
subemarginata, Nuculites, 371
Tellinopsis, 371, 145—11
subglobosus, a, um, Ancillopsis, 511, 210—10
Coelocystis, 129, 48—9–12
Gosseletina, 453, 183—32
Hemicosmites, 129
subgracile, Ectenolites, 533, 217—13
subhanieli, Eoasianites, 573
subhemisphericus, Delocrinus, 173, 62—30; 65—7
sublaevis, Anchura, 497
Bellerophon, 443, 178—18–20
Scolopodus, 240
sublamellosa, Cleiothyridina, 333, 128—3–5
sublaxus, a, Archimedes, 264, 100—7
Ophiletina, 467, 189—18–20
sublevis, Echinocaris, 657, 279—37, 38, 41
submarginata, Polypora, 264, 100—11
submcconnelli, Oxytoma, 391, 152—7
Pteria, 391, 152—7
subnasuta, um, Clinopistha, 369, 144—4
Orthodesma, 369, 144—14, 15
subnodosus, a, um, Glyptocrinus, 183
Pleurostomella, 37, 8—22
Stephanozyga, 463, 187—12
suborbicularia, Ungulina, 373
suborbicularis, Alveolites, 105
Ontaria, 373, 145—12–14
suborbiculata, Bairdia, 683, 287—38
subovatus, a, um, Alectryonia, 395, 153—20
Anisomyon, 519, 212—33, 34
Cytheridea, 689, 290—26–29
Edmondia, 373, 145—7
Glycymeris, 383, 148—14, 15
Haplocytheridea, 689, 290—26–29
Naticopsis, 475, 194—20, 21
Ostrea, 395, 153—20
Semele, 429, 171—9
subperlobata, Palmatolepis, 245, 94—41
subperuviana, Pulvinulinella, 39
subplana, Fardenia, 343, 132—36–40
Leiopteria, 385, 149—6
subquadrans, Fenestella, 264
Lyropora, 264
subquadratus, a, um, Amphiscapha, 465, 188—29–31
Amphissites, 671, 282—31
Cassidulus, 225
Christiania, 339, 129—1–7
Composita, 335, 128—13–15
Leptaena, 337
Myalina, 393, 153—8
Ophiceras, 571, 233—21–23
Orthis, 298
Plaesiomys, 298, 111—54–58
Protocardia, 425, 169—14, 15
Straparolus, 465, 188—29–31
subradiata, Eurychilina, 675, 283—17–19
subramosus, a, um, Homotrypa, 257, 97—11–13
Parisocrinus, 154, 57—20
Septastrea, 121
subramulosus, Cydrocrinus, 157, 58—2
subrectus, a, um, Cimomia, 551, 225—6
Escharopora, 267, 101—22–24
Orthonychia, 473, 193—19
Pentameroides, 305, 115—23, 24
Pentamerus, 305
Platyceras, 473, 193—19
subrostratum, Loxostomum, 35
subrotundus, Echinodiscus, 221
Lytospira, 465, 189—7, 8
subrugosus, a, um, Amphiscapha, 465, 188—34–39
Helcionella, 439, 175—5–10
Straparolus, 465, 188—34–39
subsinuatus, a, um, Hydreionocrinus, 163
Laudonocrinus, 165, 62—10; 64—10
Yunnania, 451, 183—8
subspatulatus, a, um, Barroisella, 285, 107—29–32
Lingula, 285
Ostrea, 395, 154—14, 15
Unio, 399, 158—10, 11
subspinosus, Coeliocrinus, 159, 59—1
subspinulosus, Platycrinites, 203, 78—20
substriatus, Anomalofusus, 507, 208—17
Fusus, 507
subteres, Balanocrinus, 207
subterraneus, Astacus, 699
Cancer, 699
subtilis, Hindeodella, 241
subtilita, Composita, 335, 128—9–12
subtortuosa, Gervillia, 389, 150—20
subtrigonalis, Corbula, 431, 172—3–5
subtumidus, Ageneracrinus, 209
subula, Nerinella, 495, 203—12
subulatus, a, um, Buccinum, 511
Cytherideis, 689
Michelinoceras, 537, 219—3
subumbilicata, Valvata, 487, 199—27, 28
subumbona, Emanuella, 329, 126—32, 33
subundata, Lucina, 423, 168—28
subwilsoni, Terebratula, 313
succulentus, Dendrograptus, 67
suciensis, Vanikoropsis, 483, 198—9
suessana, Beachia, 364, 142—10–14
Meganteris, 363
suessi, Agathiceras, 575
Spiriferina (var. australis), 359, 140—52–55
sulcatinus, a, um, Bellerophon, 441
Bucania, 441, 177—12, 13
Nemodon, 379, 146—48
Palaeoneilo, 377, 146—25
sulcatus, a, um, Allorisma, 414
Aulacophyllum, 101, 34—7, 8
Caninia, 101
Cranaena, 364
Cystiphyllum, 99, 33—6, 7
Delthyris, 327, 125—23, 24

sulcatus, Donax, 401
Holtedahlina, 343, 132—30-33
Lagena, 32
Leptaena, 343
Loxonema, 461
Pteria, 391, 152—1
Serpula, 32
Sulcella, 685, 288—24
Synbathocrinus, 151, 56—17
Trigonirhynchia, 313, 120—10-12
Turbinolia, 121
Venus, 401
sulciferus, Spathognathodus, 244, 94—2
sulcomarginata, Bembexia, 457, 184—25, 26
sulzeri, Trilobites, 609
summacuminata, Bairdia, 683, 287—23
sumnerensis, Lophospira, 449, 182—14, 15
Loxoplocus, 449, 182—14, 15
sundaicum, Paralegoceras (var. evoluta), 573
supera, Lepidocyclina, 43, 13—4, 5
superbus, a, um, Aspidites, 577
Binuria, 335, 128—29-33
Coosia, 623, 264—25
Halobia, 393, 153—2
Lumbriconereites, 229, 91—45
Olenoides, 613, 256—20
supinus, Oklahomacrinus, 167, 56—24; 62—19
supracingulata, Eotomaria, 455, 184—15-17
supraplicatus, Gyrodes, 483, 198—10-12
surcularia, Syringopora, 115
sussexensis, Kloedenia, 675, 282—10; 283—40
swallovanus, Archimedes, 264
swallovi, Ammonites, 591
Blothrocrinus, 158, 58—11
Metoicoceras, 591, 245—6, 7
Schizophoria, 357, 140—8, 9
swallowi, Phillipsia, 651, 276—4-6
swantonensis, Paterina, 287, 108—4-7
swartzi, Dizygopleura, 679, 284—31-35
Kyammodes, 677, 284—40
sweeti, Holopea, 447
Sinuopea, 447, 180—10
swezeyi, Scaevogyra, 439, 175—21-23
swifti, Pallium (var. nutteri), 407, 161—19
Pecten (var. nutteri), 407, 161—19
swinderniana, Agaricia, 109
symmetricus, a, um, Ancyrognathus, 244, 94—27, 28
Dizygopleura, 679, 284—36, 37
Holopea, 469, 192—8
Icriodus, 245, 94—65
Juresania, 350, 137—4, 5
Micropedina, 226, 88—11-14
Platycrinites, 203, 78—26
Polygnathus, 245, 94—35
Stuartwellercrinus, 175, 60—19
Trichognathus, 241
symonensis, Mazapilites, 585, 241—3-5
syringoporoides, Tetradium, 103
syrtalis, Chonetes, 345, 134—21-23
szajnochai, Dalmanella, 357
Isorthis, 357

T

tabulatus, a, um, Neptunea, 505, 207—7
Sulcosipho, 505, 207—7
Syringopora, 115, 42—3, 4
Turbo, 457
Worthenia, 457, 185—4
tacitus, Oenonites, 231, 91—53
takwanensis, Emanuella, 329
tampae, Peyrotia, 493, 201—19
Turritella, 493, 201—19
tantilla, Periporosella, 271
tarri, Agassizocrinus, 177
Paragassizocrinus, 177, 56—31
taylorana, Lingulina, 32, 6—10
taylorensis, Ammobaculites, 15, 1—12
Haplophragmium, 15, 1—16
Lituola, 17, 1—15
taylori, Rhynchopora, 359, 140—24-26
tecticosta, Ostrea, 395, 154—12, 13
tegminals, Crinoid, 209
tehamaensis, Oxyteuthis, 597, 250—11, 12
tehuantepec, Apiocrinus, 205, 79—7
telemus, Monoculus, 517
telleri, Taxocrinus, 177, 68—5
tellinoides, Anomia, 409, 163—15, 16
telum, Dictyophyton, 55
Prismodictya, 55, 16—15
tenax, Fenestrellina, 263, 99—29, 30
tenella, Neozaphrentis, 91, 27—18-20
Zaphrentis, 91
tener, Turrilepas, 695, 293—1-3
tenera, Andrarina, 605, 259—12, 13; 276—25
Macoma, 429
Trigonostoma, 514, 211—35
teneris, Perimestocrinus, 161, 64—11
tennesseeae, Catillocrinus, 149, 55—2
tennesseensis, Calceola, 99, 32—17, 18
Centrocrinus, 181
Ceratopea, 447, 181—14-16
Euryocrinus, 179, 68—23
Hormocrinus, 181, 54—6
Lampterocrinus, 187, 72—18
Leptellina, 335, 128—21-24
Merista, 331, 126—56-59
Periechocrinites, 189, 75—15
Pisocrinus, 147, 54—18
Rhizophyllum, 99, 32—17, 18
Strophomena, 337, 130—15-18
Trigonirhynchia, 313, 120—8, 9
tenticulum, Spirifer, 321
tentor, Eretmocrinus, 195, 76—12
tenuibrachiatus, Pycnosaccus, 181, 69—11
tenuiceps, Semicoscinium, 263, 99—32
tenuicinctus, um, Coleolus, 526, 214—19
Coleoprion, 526
tenuicollis, Cladochonus, 113
tenuicostata, Limnaea, 519
Pleurolimnaea, 519, 212—22, 23
tenuifilatum, Actinostroma, 59, 18—4-6
tenuilineata, Bucanopsis, 443, 179—3-5
tenuilobatus, Ammonites, 583
tenuimurale, Hemiphragma, 259, 98—33, 34
tenuiradiatus, Actinocrinus, 127
Palaeocystites, 127, 47—16-19
tenuirama, Rhombopora, 267, 101—9-11
tenuirugosus, Polygonal, 209, 79—22
tenuis, Climacograptus, 73
Helopora, 265
Rhapalonaria, 250
Volborthella, 531, 217—6-8
tenuisculptus, Actinocrinites, 193, 77—14
tenuiseptatum, Heliophyllum, 97
tenuiseptum, Cameroceras, 535, 218—7, 8
tenuistriatus, a, um, Ammonites, 587
Cardium, 425, 169—2-4
Cypricardella, 415, 166—2
Granocardium, 425, 169—2-4
Parallelodon, 379, 146—45
terebra, Loxonema, 461, 186—21
Turbo, 491
terebrata, Zaphrentis, 93
terebratuloides, Buchia, 395, 153—15, 16
terebreviformis, Subulites, 477, 195—17
terebriformis, Archimedes, 264, 100—4
termieri, Yunnania, 451
terminalis, e, Allorisma, 414, 165—10, 11
Orbicula, 289
Trematis, 291, 109—13-15
terranovicus, a, Conocoryphe, 609, 253—5
Hyolithes, 525, 215—27-30

tersa, Resserella, 353, 138—19, 20
tesselatus, a, Cancellaria, 515
Cryptolithus, 643, 267—2–5
Mitra, 509
tessini, Paradoxides, 615
testudinarius, a, Marsupites, 207
Orthis, 353
tetrahedra, Wellerella, 315
teucer, Conocephalites, 605
Ptychoparia, 605, 253—6
texanus, a, um, Ammonites, 593
Arcopagia, 425, 169—20
Arionellus, 635
Bathyurus, 635
Boesites, 569, 233—6, 7
Buccitriton, 501, 206—6
Cyprimeria, 425, 169—20
Daraelites, 569
Dimorphoceras, 575
Dorocidaris, 219, 226, 83—8–11
Dungulia, 122, 45—33–37
Enallaster, 226, 86—16–18; 89—20, 21
Endelocrinus, 173, 65—10
Exogyra, 397, 156—7, 8
Haplostiche, 13, 1—7, 8
Hemiaster, 225, 87—7–9
Huenella, 301, 114—15
Lepidocyclina, 47, 13—6
Lophosmilia, 121, 45—27–29
Loriolia, 226, 89—13, 14
Macraster, 225
Malonophyllum, 87
Monopleura, 421, 168—6, 7
Mortoniceras, 593, 247—6–8
Neithea, 405, 161—2
Neodimorphoceras, 575, 236—5, 6
Neospirifer, 325, 125—3, 4
Orbitolina, 31, 6—2
Pecten, 405, 161—2
Phymosoma, 219, 226, 83—17–19; 89—9
Pleurocora, 119, 44—13
Protocardia, 425, 169—16
Pseudoschwagerina, 25, 4—28, 29
Pulvinulinella, 41, 10—10
Reophax, 13, 1—6
Salenia, 219, 226, 89—4, 5
Syntrophia, 301
Toucasia, 421, 168—3–5
Tricrepicephalus, 635, 262—25–28
Volutoderma, 509, 209—22
Waagenophyllum, 89, 25—30
texasensis, Ethelocrinus, 175, 65—31
texta, Syringothyris, 363, 142—27–29
textilis, Actinopteria, 391, 152—17
Actinopteria (var. arenaria), 391
Bucanopsis, 443, 179—1, 2
Chiton, 527
texturata, Ophiura, 213
Volutoderma, 509
thalloide, Dentalium, 523, 214—17
thallus, Cadulus, 523, 214—30
thedfordensis, Microcyclus, 85, 23—19–23
Mucrospirifer, 321, 122—15, 16
thiemi, Forbesiocrinus, 181
thoas, Spyroceras, 541, 221—7
thomasi, Clionoides, 57, 17—20
thompsoni, Cornuspira, 29, 5—9
Cyrtogomphoceras, 561, 230—14
Olenellus, 613, 253—4
Olenus, 613
Tulotoma, 487, 199—23–26
thori, Beyrichiopsis, 685, 288—10–13
thouarsi, Eucidaris, 89—41, 42
thureaui, Didymograpsus, 69
Goniograptus (var. postremus), 69, 21—2
tiaraeformis, Ichthyocrinus, 183
tibeticus, um, Aulosteges, 349
Ophiceras, 569
tigris, Cypraea, 500
tinctum, Epitonium, 481, 197—24, 25
Nitidiscale, 481, 197—24, 25
tinea, Beyrichona, 657, 278—6
tioga, Cariniferella, 353, 138—34–38
tippana, Aphrodina, 427, 170—17, 18
Dreissena, 413, 164—28–30
Fusus, 507
Harpago, 499
Meretrix, 427, 170—17, 18
Turritella, 493
titan, Ostrea, 397, 154—21, 22
tombigbeensis, Cytherelloidea, 687, 289—6
tomlinsoni, Bythocypris, 683, 287—61
tonolowayensis, Beyrichia, 675, 283—33
tonsum, Aspidodiadema, 89—37
tontoensis, Anoria, 605, 258—18
Dolichometopus, 605
toreuma, Glyptagnostus, 600
tornatilis, Voluta, 515
torquatus, Schistocrinus, 165, 62—12; 64—8
torquia, um, Campophyllum, 91
Caninia, 91, 28—4–6
torrubiae, Tylostoma, 483
torta, Euritina, 275, 104—2
tortilis, Cyrtospira, 477, 195—16
Subulites, 477, 195—16
Tretocycloecia, 251, 96—2, 3
totuliformis, Ophileta, 449, 181—25
tourteloti, Nebraskacrinus, 159, 60—13
trabeatus, Fusus, 500
Levifusus, 501, 205—20
trachea, Dentalium, 491
tranquebaricum, Buccinum, 503
transitans, Paedeumias, 615, 254—18
transversalis, Plectodonta, 335, 128—34–36
transversus, a, um, Atrypa, 445
Bradfordoceras, 551, 226—10
Dinorthis, 298, 111—45, 46
Naticopsis, 475, 194—24
Orthambonites, 295
Paryphorhynchus, 311
Terebratalia, 365, 143—50, 51
trapeca, Prototreta, 289, 108—29–33
trapezoidalis, Astarte, 417, 166—25, 26
trapezoides, Thracia, 415, 165—24, 25
traquairii, Cheirodata, 227
Protocaudina, 227, 90—11–13
traski, Acteon, 515, 211—32
traversensis, e, Diversophyllum, 93, 28—27–29
Zaphrentis, 93
travisensis, Montastrea, 119, 44—3
trechmanni, Pseudorbitoides, 45
trentonensis, e, Cameroceras, 535
Coeloclema, 253, 96—8
Conularia, 77, 22—29, 30
Craniops, 293
Hormotoma, 459, 185—23, 24
Platystrophia, 299, 113—28, 29
Rafinesquina, 337, 129—24
Tetralichas, 654, 270—9, 10
Vellamo, 297, 106—14; 111—32–35
triacontadactylus, Actinocrinites, 193
triangularis, Ambolodus, 237, 93—7, 8
Gaudryina, 18, 2—10
Healdia, 682, 287—3
Lumbriconereites, 229, 91—33
Valvulina, 18
triangulatus, Stereocrinus, 201, 74—23
triangulus, Ecculiomphalus, 467, 189—21, 22
tribuloides, Cidarites, 219
tribulosum, Orthonychia, 473, 193—8
Platyceras, 473, 193—8

tribulus, Murex, 505
tricarinatus, a, um, Leaia, 660, 279—30, 31
Pharkidonotus, 445, 179—21–23
Textularia, 18
Trochonema, 451, 182—32
Trochonemopsis, 451, 182—32
Verneuilina, 18
tricenaria, Hesperorthis, 297, 111—1–5
Orthis, 295
triceps, Neoshumardites, 575
trichotomum, Lithodendron, 117
tricollis, Bellornatia, 669, 281—51, 52
tricornis, Cryptograptus, 75, 22—11
Diplograptus, 75
Kyammodes, 677, 284—38, 39
tritcostatus, a, Ecphora, 505, 208—5
Lyriopecten, 403, 160—13
tridens, Scaphites, 591
triforata, Crisisina, 251, 95—23, 24
Idmonea, 251, 95—23, 24
trigona, Allomorphina, 41
trigonalis, Epiaster, 225
Ostrea, 397, 154—19, 20
trigonostoma, Delphinula, 514
trigonus, Palinurus, 699
trilatera, Clavulina, 18
trilateralis, Ranapeltis, 682, 286—45–47
trilineata, Arca, 383, 148—10
trilira, Turritella, 493, 201—13
trilix, Bembexia, 457, 184—27, 28
trilobatus, a, Bucanella, 441, 176—15, 16
Codaster, 134
trilobitus, Anthracomartus, 709, 300—3, 4
triloculina, Ammochilostoma, 17
Glyphostomella, 17, 1—18, 19
trimera, Pseudolepidina, 43, 12—3, 4
trinitiense, Cytheropteron, 691, 292—8–10
Eocytheropteron, 691, 292—8–10
trinodiferus, Calytraphorus, 500, 204—7, 8
trinuclea, Composita, 335, 128—16–20
triplesana, Stricklandia, 307, 117—1–3
triplicata, Creonella, 480, 197—17, 18
triptum, Uromitra, 509, 210—17
Vexillum, 509, 210—17
tripunctatus, Tricrepicephalus, 635, 262—11
triqueter, Nuculites, 377, 146—15, 16
triquetra, Gosselettia, 387, 150—6
Prismopora, 270, 102—21
triseptatus, Sowerbyites, 335, 128—25–28
trisulcatum, Stroboceras, 545, 223—2, 3
tritone, Busycon, 501, 206—14
trivolvis, e, Atopochara, 713, 303—13
Ryticeras, 545, 222—16–18
trivolvus, Fusus, 501
Perissolax, 501, 206—4
trochidiformis, Rotalia, 39
trochiformis, Paludotrochus, 485, 199—12, 13
Viviparus, 485, 199—12, 13
trochus, Eoptychia, 461, 186—26
troosti, Bellerophon, 443, 178—12–14
Cacabocrinus, 201
Clarkeocrinus, 201, 74—1
tropidophorus, a, Murchisonia, 449
Pleurophorus, 415, 165—31
troyensis, Fordilla, 660, 279—5, 6
trunca, Tholiasterella, 56, 16—17, 18
truncatus, a, um, Bythocypris, 683, 287—39–41
Cucullaea, 379, 147—3
Idonearca, 379, 147—3
Ischyrodonta, 381, 148—3, 4
Kirkbyella, 671, 282—45, 46
Mya, 431
Productella, 347, 135—21–23
Seminolites, 683, 287—9
Sphenotus, 414, 165—3
Xestoleberis, 693, 292—36–40
tuberculatus, a, um, Agnostus, 675
Battus, 675
Beyrichia, 675, 283—32
Busycon, 501, 206—18
Chiton, 527
Facetal, 209, 79—15
Kochiella, 613
Odontopleura, 651, 271—11–13
Rhodocrinites, 185, 73—6
Stromatoporella, 61, 18—21, 22
Urceolabrum, 480, 197—1
tuberculosa, Nerinea, 495
Trematopora, 261, 99—14–16
tuberosus, a, um, Emmonsia, 109, 38—6, 7
Entomis, 687
Eucladocrinus, 205, 78—30
Gilbertsocrinus, 187, 73—1, 2
Hydnoceras, 55, 16—19
Lingulina, 37
Mamillopora, 276, 104—12, 13
tubifer, Murex, 503
tubifera, Fletcheria, 103
tubuliferus, a, Cremacrinus, 145, 55—7
Tubulibairdia, 685, 288—6, 7
tulipa, Murex, 507
tumens, Venus, 427
tumescens, Neidium, 301—37
tumidulus, Decadocrinus, 169, 59—7
tumidus, a, um, Acratia, 685, 288—14–16
Astrodaspis, 223, 85—4, 5
Bonniella, 609, 256—19
Cardiodella, 239, 93—17, 18
Cardiodus, 237
Cibolocrinus, 183, 56—15
Cyathocrinites, 154, 57—27
Eunicites, 229, 91—30
Hybocrinus, 151, 53—3
Leperditella, 664, 280—32–34
Triticites, 23, 4—30–32
Trophocrinus, 149, 56—11
tumulus, Cypraea, 500, 205—5, 6
tuomeyana, Natica, 483
Vanikoropsis, 483, 198—7, 8
turbinatus, a, um, Cibolocrinus, 175
Favosites, 107, 37—5
Lichenopora, 251
Muricites, 459
Platyceras, 473, 193—13, 14
Platyostoma, 473, 193—13, 14
turbiniformis, Euconospira, 457, 185—11
Pleurotomaria, 457
turgidus, a, um, Cadulus, 523, 214—26
Girtyella, 365, 143—21–23
Strepsidura, 501
turritella, Stegocoelia, 459, 185—19
typicalis, Antagmus, 605, 253—6
Apographiocrinus, 158, 56—21; 62—22
Atactoporella, 257, 97—3–5
Bryantodina, 243, 94—25
Climacograptus, 73, 21—34
Coleoloides, 526, 214—20, 21
Euptychaspis, 625, 264—27
Lonchodina, 243
Nothognathella, 243, 94—26
Oedorhachis, 601, 251—18
Oryctocephalites, 613, 257—14, 15
Pachyaspis, 615, 255—7, 8
Polygnathellus, 245, 94—52–54
Ranapeltis, 682
Saukiella, 633, 260—26–29
Schizambon, 287, 108—21–24
Taxioura, 617, 259—23, 24
Zacanthoides, 619, 257—20–22
Zittelella, 51
typicus, a, um, Acratia, 685, 288—17, 18
Atactotoechus, 257, 258

typicus, Bicaspis, 607, 259—17, 18
Bryantodus, 243
Clappaspis, 609, 255—12
Deltatreta, 298
Dichognathus, 243, 94—10
Diparelasma, 299, 112—31, 32
Eopteria, 659
Girtycoelia, 56, 17—12, 13
Marginifera, 351
Ozarkina, 465, 188—43
Ozarkodina, 244
Palaeacmaea, 437, 175—4
Schizopea, 447, 180—12–14
Soleniscus, 479, 196—15, 16
Spathella, 414, 165—7
Tritoechia, 298, 112—9–14
Turbonilla, 481
typus, a, um, Allocrinus, 200, 73—18
Ampheristocrinus, 154, 54—28
Arapahoia, 619, 263—17, 18
Bassleratia, 669, 281—54–57
Beckwithia, 705, 298—1
Cibolocrinus, 181, 56—16
Ctenocrinus, 200
Curtognathus, 239
Erismodus, 237
Erisocrinus, 173, 62—27; 65—28
Gilbertsocrinus, 187, 73—3
Isotomocrinus, 149, 52—11
Kirkbyella, 671, 282—47
Marjumia, 613, 258—17
Mastigobolbina, 675, 283—49, 50
Merista, 331, 126—60–62
Merocrinus, 155, 53—16
Microcoelodus, 241, 93—70
Orthoceras, 539
Ottawacrinus, 158, 53—24
Palaeanatina, 371, 144—29
Palaeocaris, 697, 294—7, 8
Phyllograptus, 70, 21—11
Schultzicrinus, 154, 57—5, 6
Striacoceras, 539, 220—6, 7
Sygcaulocrinus, 145, 52—7
Syringothyris, 363
Tanaocrinus, 189, 72—3

U

uberis, Mendacella, 355, 138—39–42
Orthis, 353
uddeni, Neozeacrinus, 167, 62—15; 63—22
Plummericrinus, 161, 63—18
Prorichthofenia, 351, 138—43–45
Pseudoschwagerina, 25, 4—25, 26
Schwagerina, 25
Timorites, 577, 237—2, 3
uhleri, Lucina, 423, 168—26, 27
uhligi, Spiticeras, 589, 244—11, 12
Streblites, 583, 240—15, 16
ulrichi, Camerocrinus, 209, 79—34
Climacograptus, 73, 21—36
Cyathus, 665, 280—45–48
Cyrtograptus, 77, 22—25
Dekayella, 258
Hercoglossa, 549, 225—7–9
Homotelus, 647, 268—8
Metaconularia, 79, 22—31
Newsomella, 414, 164—34, 35
Onychocrinus, 179, 69—15
Plaesiomys, 298
Solenopleurella, 617
umbellata, Discoporella, 273, 103—24
Lunulites, 273
umbellifera, Aulopora, 113
Romingeria, 113, 40—10, 11
umbilicatus, a, um, Adeonellopsis, 276, 104—18
Anomphalus, 473, 193—27–29
umbilicatus, Domatoceras, 549
Drillia, 513
Eukloedenella, 677, 284—5–8
Euomphalus, 465, 188—18, 19
Helicotoma, 467, 189—16, 17
Pleurotomaria, 451
Roubidouxia, 447, 180—6
Straparolus, 465, 188—18, 19
Trochonema, 451, 182—33
umbonatus, a, um, Ambocoelia, 329, 126—21–26
Cyrtina, 359, 140—40–42
Inoceramus, 389, 151—13, 14
Orthis, 329
Volviceramus, 389, 151—13, 14
Xanthiopyxis, 301—14
umbrosus, Actinocrinus, 193
Teleiocrinus, 193, 77—1
umzambiensis, Meretrix, 427
unabundus, Inoceramus, 389, 151—9, 10
unca, Crepicephalus, 635
Uncaspis, 635, 266—25–27
undatus, a, um, Buccinum, 503
Clionychia, 387, 150—4
Cymella, 415, 165—23
Pholadomya, 415
Plectoceras, 543, 222—10
Plectoceras (var. occidentale), 543
undosus, a, um, Alveolites, 105, 36—9
Collenia, 717, 303—33, 34
Eulepidina, 47, 13—13
Lepidocyclina, 47, 13—13
Pterinopecten, 403, 160—6–8
undulato-plicatus, Inoceramus, 389, 151—2
undulatus, a, um, Aulacera, 63, 19—16, 19, 20
Beatricea, 63
Chaetetes, 259
Conularia, 77, 22—35, 36
Cyrtoceras, 545
Halloceras, 545, 222—14
Lytospira, 465, 189—5, 6
Orthonota, 369, 144—9, 10
Phragmodus, 241, 93—49, 50
undulifera, Tellina, 429, 170—26
unguiformis, e, Platyceras, 473, 193—5–7
Proplina, 437, 174—7, 8
unguis, Patella, 285
ungula, Belosepia, 597, 250—19–21
Bollia, 667, 281—33–35, 67–69
Homalophyllum, 91, 28—18–22
Zaphrentis, 91
uniangularis, e, Goniatites, 567
Tornoceras, 567, 231—12, 13
uniangulata, Helicotoma, 467, 189—14, 15
unicornis, Dorycrinus, 195, 76—5
Primitiella, 665, 281—5–7
unicostata, Leptaena, 343, 132—26, 27
unicus, um, Abrotocrinus, 159, 59—15
Lithostrotionella, 89
unilineata, Terebra, 511, 210—24, 25
unioniformis, Isocardia, 373
unionoidea, Ischyrodonta, 381, 148—1, 2
unisulcata, Atrypa, 333
Pentagonia, 333, 127—37
universa, Candorbulina, 41, 11—2, 3
urania, Burnetia, 621, 263—25, 26
Ptychoparia, 621
urei, Bellerophon, 445
Spirifer, 329
Tabulipora, 259
urii, Cidaris, 217
urna, Apical, 209, 79—21
utahensis, Anomalorthis, 298, 112—4–8
Cryptorhytis, 507, 208—9
Fasciolaria, 507, 208—9
Kiwetinokia, 53, 16—11
Lima, 409, 163—12

utahensis, Tenticospirifer, 321, 121—45, 56
uvasana, Crassatellites, 419, 167—11
Pitar, 427, 170—21
Turritella, 493, 202—15

V

vadosus, Crassatellites, 419, 167—1-3
vagans, Hyperammina, 15
valenciennesii, Eupatagus, 226
valens, Vasocrinus, 154, 57—2
valeriae, Dibunophyllum, 89, 25—23-25
validus, a, Modiolopsis, 409, 163—28
Scytalocrinus, 169, 59—11
vallata, Zygosella, 677, 284—3, 4
vancortlandti, Carabocrinus, 153, 53—6
vancouverensis, Arniotites, 581, 239—3
Elysastraea, 119, 43—29-31
vanhornei, Phacelocrinus, 171, 60—5
vaningeni, Cylindrotopsis, 479, 196—7
vannoiti, Thylacocrinus, 185
vanuxemi, Agoniatites, 565, 231—9, 10
Aturia, 549, 225—12, 13
Crispella, 327, 125—25
Goniatites, 565
Trimerus, 654, 272—32
vanvleeti, Aviculopecten, 401, 159—24
varia, Constellaria, 259, 98—14, 15
Phyllodictya, 269, 102—8-10
variabilis, Aulosteges, 349
Balanophyllia, 122, 46—17-19
Douvillinella, 341, 132—12, 13
Linthia, 226, 87—17-21
Turritella, 493, 202—8
varians, Apatognathus, 240, 93—59-61
Camerella, 303
Diaperoecia, 251, 95—26
Nereidavus, 229, 91—46
Ptychospirina, 475, 194—3-5
Taphrognathus, 246, 94—66-68
Zittellella, 53, 15—8, 9
varicosum, Cyclonema, 471, 192—25, 26
varicus, Bilobites, 355, 138—49
variolata, Chonetes, 345
variosum, Cytheropteron, 693, 292—11-13
varro, Dolichometopus, 625
Housia, 625, 265—9
vasulites, Bellerophon, 443
vaughani, Acteon, 515, 211—29
Cythereis, 688, 289—13-15
vaupeli, Diamesopora, 253
Nicholsonella, 259, 98—31, 32
velascoensis, Allomorphina, 89, 10—12
velatus, a, um, Calyptraphorus, 499, 205—1-3
Calyptraphorus (var. compressus), 499
Calyptraphorus (var. nodovelatus), 205—1-3
Rostellaria, 499
velebitana, Mizzia, 302—1
velus, Taonurus, 719, 303—25
vendryesiana, Bulla, 517, 212—24
venosa, Carnarvonia, 655, 277—5
Rhapalonaria, 250, 95—1
ventralis, Kloedenia, 675, 283—39
Monoceratina, 693, 292—26-30
Saffordia, 371, 144—33, 34
ventriclefta, Pyxiprimitia, 665, 281—8, 9
ventricornis, Zygobeyrichia, 675, 283-41
ventricosus, a, um, Actinocrinus, 193
Cavolina, 517, 213—25-27
Coeliocrinus, 159, 55—20
Cuspidaria, 415, 165—26
Cyrtospira, 477, 195—21
Fusispira, 477
Naticopsis, 475, 194—17-19
Nucleospira, 331, 127—8, 9
Nucula, 375, 145—26, 27
Physetocrinus, 193, 77—7
ventricosus, Platyceras, 473, 193—3, 4
Platyostoma, 473, 193—3, 4
Scaphites, 591, 244—10
Spirifer, 331
Strobeus, 479
Subulites, 477, 195—21
Triticites, 23, 4—34-36
Uncinulus, 313, 119—38-41
Whitella, 381, 147—21, 22
ventripunctata, Zygobeyrichia, 675, 283—42-44
ventrocarinata, Valcourea, 297, 111—25, 26
ventrosa, Eurychilina, 675, 283—21, 22
venulosa, Bailiella, 607, 276—20
venustula, Hypothyridina, 315, 120—5-7
venustus, a, um, Bailiaspis, 607, 253—19
Fimbrispirifer, 323, 122—32-34
Pararca, 373
Pecten, 405, 161—13
Spirifer, 323
Stenoscisma, 315, 120—38-40
vermicauda, Hymenocaris, 655
vermicula, Helminthozyga, 463, 187—14, 15
vermicularis, Serpula, 231
Trigonopora, 276
vermontanus, Olenellus, 613, 253—1
vermontensis, Centropleura, 609, 254—16
verneuili, Anastrophia, 303, 114—48-52
Billingsastraea, 97, 31—7
Nucleocrinus, 135, 51—3-6
Orthis, 297
Pentamerus, 303
Phillipsastraea, 97
Spirifer, 321
verneuilianum, Baryphyllum, 85, 23—34-37
Eridophyllum, 89
Macrocrinus, 197, 76—19
verrucosus, a, um, Actinocrinites, 193, 76—1
Cribrilina, 275, 104—17
Dalmanites, 643, 273—27-29
Platycrinites, 203, 78—18
Reptolunulites, 275, 104—9, 10
Venus, 425
vertebralis, Huronia, 553, 227—7
vertebroides, Turritella, 491, 201—9-12
verticalis, Scolithus, 234, 92—35
verticillata, Syringopora, 115, 41—21
verus, a, um, Astartella, 417, 166—15
Delocrinus, 173, 65—6
Eumetria, 361, 141—38-41
Retzia, 361
Rhodocrinites, 185
Sinuopea, 447, 180—8
vesicularis, Discorbis, 37
Gryphaea, 397, 155—12
Orbitolina, 43
Ostrea, 397
vesiculata, Hallia, 93, 29—19
vesiculosum, Clathrodictyon, 59, 61, 18—12
Clathrodictyon (var. minutum), 59, 18—13
Cyathophyllum, 101
Cystiphyllum, 99, 101
Mesophyllum, 101, 33—16, 17
vesperalis, Diabolocrinus, 185, 72—16
vespertinus, a, Ammonites, 593
Ostrea, 397, 155—3
veternus, Planorbis, 519, 213—20, 21
vetulum, Campeloma, 487, 199—20, 21
vetusta, Helix, 521, 213—18, 19
Mesalia, 495, 203—6
Pileopsis, 473
Solemya, 369, 144—1, 2
vicina, Strophomena, 337, 130—6, 7
vicksburgensis, Acrohelia, 121, 44—10, 11
Cytherelloidea, 687, 289—2
Spirillina, 37, 9—6
vicksburgica, Floridinella, 273, 275, 104—5

vicksburgica, Steganoporella, 275, 104—6
Tubucellaria, 275, 104—3, 4
victoriensis, Leopoldia, 589, 243—6, 7
victoris, Kossmatia, 587, 243—1-3
vigilans, Dalmanites, 643, 273—13-16
Vogdesia, 654, 268—20, 21
vincta, Murchisonia, 459, 186—3
vinitaensis, Healdia, 682, 287—1, 2
virgatum, Araeonema, 471, 192—32, 33
Auriptygma, 479
Leptoptygma, 479, 196—19
virginarius, Plaxocrinus, 163, 63—2
virginiana, Egouena, 509, 210—6
Marginella, 509, 210—6
virginicus, a, um, Bonniella, 609, 256—17
Lemintina, 491, 201—3
Prozacanthoides, 617, 257—7
virginiensis, Ptychoglyptus, 337, 128—37, 38
viridis, Pinnularia, 301—19
vitellus, Nerita, 485
vitruvia, Liospira, 453, 183—9-12
vittatus, Euphemites, 445, 179—29-31
viverosi, Idoceras, 585, 242—6, 7
viviparus, a, Helix, 485
Spirillina, 37
volborthi, Camerella, 303, 114—36-38
volkelianus, Anthracomartus, 709
volutatus, Ecculiomphalus, 467, 189—28-30
vomer, Gryphaeostrea, 397, 155—1, 2
Ostrea, 397, 155—1, 2
vulgaris, Balanus, 695
Chara, 713
Chara (var. foetida), 713
Cucullaea, 379, 147—7, 8
Cyclopina, 705, 298—5, 6, 12
Idonearca, 379, 147—7, 8
Mimella, 299
Myophoria, 401
Zanthopsis, 701, 297—23-25
vulgatus, Delocrinus, 173, 65—19
vyschetzki, Trigonia, 401, 159—8

W

waageni, Xenodiscites, 569, 233—10
Xenodiscus, 569, 233—13-15
wabashensis, Marginifera, 351, 137—27, 28
wachsmuthi, Barycrinus, 154, 57—18
Batocrinus, 195, 75—6
Catillocrinus, 149, 55—1
Linocrinus, 167, 59—3
Nipterocrinus, 181, 69—2
Synbathocrinus, 151, 55—10
wacoensis, Kingena, 365, 143—32-34
Lima, 409, 163—11
wahtubbeanus, Chlamys, 407
Pecten, 407
walcottanus, a, um, Holmia, 619
Olenellus, 619
Wanneria, 619, 253—20
walcotti, Aphelaspis, 619, 263—31
Drumaspis, 623, 264—33
Kingstonia, 627, 263—1, 2
Lingulepis, 285, 107—6, 7
Productella, 349, 135—24-26
Stromatocystites, 129, 49—11
waldronensis, Parmorthis, 353, 138—31-33
walkeri, Acanthograptus, 67
waltonensis, Aphera, 515, 211—36
Conus, 513, 211—6, 7
wandeli, Pourtalesia, 89—30-32
wannensis, e, Glabrocingulum, 455, 184—24
Neozaphrentis, 91, 27—23-26
wanneri, Yorkia, 287, 108—18-20
wapanuckensis, Paraparchites, 664, 280—24, 25
wardensis, Cytherura, 689, 291—20-22
warrenana, Cymbophora, 431, 171—21, 22
warreni, Mariacrinus, 199
Scaphites, 591, 244—6
Trupetostroma, 59, 18—10, 11
wartae, Perisphinctes (var. antecedens), 587, 242—10-12
washburnei, Schizopea, 445, 180—11
washingtonensis, Nuculana, 377, 146—35
washitae, Macraster, 225, 226, 88—9, 10
washitaensis, Gryphaea, 397, 155—6, 7
watersi, Hastigerinella, 41, 11—7
watersianus, Rhodocrinites, 185, 73—8
wauwatosense, Geisonocerina, 539, 219—9
Orthoceras, 539
weatherfordensis, Paracypris, 687, 288—53, 54
webbervillensis, Vaginulina, 32, 6—16
webbi, Lumbriconereites, 229, 91—36
weedi, Ehmania, 609
welleri, Cheirurus, 641, 272—11, 12
Eoasianites, 573, 235—13, 14
Goniologoceras, 573, 234—22, 23
Scalarituba, 234, 92—31, 32
wetherbyi, Poteriocrinus, 171
Tholocrinus, 167, 59—4
wetherelli, Acteocina, 515
wewokana, Cytherella, 685, 288—32
wheeleri, Asaphiscus, 607, 258—9
Schizodus, 401, 159—1, 4
whidbornei, Kyammodes, 677
whiteavesi, Aparchites, 664, 280—20
Eutaxocrinus, 177, 68—16
Hormotoma, 459, 185—29
whitei, Cardium, 423, 169—6
Epiaster, 225, 226, 87—1-3; 89—6
Ethmocardium, 423, 169—6
Haustator, 491, 201—6
Lucina, 423, 168—24
Metacypris, 693, 291—38-42
Metoicoceras, 591, 245—8-10
Periechocrinites, 189, 75—14
Turritella, 491, 201—6
whitfieldi, Austinella, 298
Chariocephalus, 621, 264—11-13
Glossograptus, 75, 22—19
Hemiphragma, 259, 98—25, 35
Perissolax, 501, 206—1-3
Placenticeras, 595, 249—1, 2
Platycolpus, 629, 260—20, 21
Streptacis, 463, 187—22-24
Taxocrinus, 177, 69—6
whitii, Rhynchonella (var. praecursor), 309
Stegerhynchus, 309, 118—31-33
whitneyi, Astrocoenia, 115, 42—16
Cyrtospirifer, 321, 121—53-55
Ethmophyllum, 57, 17—19
Lithostrotion, 89, 26—4, 5
Medlicottia, 569, 233—8, 9
Omphalotrochus, 467, 191—21
Peregrinella, 317, 120—64, 65
whortani, Artinskia, 569, 232—16, 17
wichitaensis, Chariocephalus, 621, 264—14, 15
wilckensiana, Beyrichia, 675
wilcoxensis, Spiroloculina, 29, 5—6
wildridi, Aulacosphinctes, 587, 242—14, 15
williamsi, Natica, 485, 199—5, 6
Tellina, 429, 170—24, 25
williamsoniana, Cytherella, 687
Cytherelloidea, 687, 289—1
wilsoni, Climactichnites, 719, 303—37
Cyathocrinites, 154, 54—21
Laurelocrinus, 200, 73—19
Mysticocrinus, 153, 54—23
winchelli, Atactotoechus, 258
Favosites, 107, 37—3, 4
winslovi, Temnocheilus, 547, 224—1, 2
wintoni, Bigenerina, 17, 2—3
wisconsensis, Idahoia, 625, 265—17
wisconsinensis, Haplograptus, 69, 20—7, 8

wisconsinensis, Lophospira, 449, 182—8, 9
Loxoplocus, 449, 182—8, 9
wistae, Nevadocoelia, 51, 15—16, 17
wolfcampensis, Aulosteges, 349
woodfordi, Colpocaris, 657, 279—17–19
Spathiocaris, 659, 279—25–29
woodi, Arenicolites, 234, 92—29, 30
woodiana, Mazonia, 709, 300—6–9
woodmani, Pachyphyllum, 97, 32—1, 2
Pentremites, 135
Tricoelocrinus, 135, 51—13–16
Troostocrinus, 135
woodwardensis, Eucythere, 689, 291—16, 17
Loxoconcha, 691, 291—29–31
woolgari, Ammonites, 593
Prionotropis, 593, 247—1, 2
woolmani, Trochocyathus, 121, 45—5–7
woolworthana, Schuchertella, 343, 132—49–51
woosteri, Cedaria, 621, 264—8–10
wordensis, Parafusulina, 25
wortheni, Agaricocrinus, 195, 76—22
Archimedes, 264, 100—3
Pseudozygopleura, 461, 187—3–5
Rhineoderma, 455, 183—29
Rhodocrinites, 185, 73—11
Stegocoelia, 459, 185—20
wortheni, Zeacrinites, 165, 61—2
wratheri, Gryphaea, 397, 155—20, 21
wrighti, Borestes, 455
Microptychis, 461
wrightianus, Chiton, 695
wrightii, Caryocaris, 657
Turrilepas, 695
wyomingensis, Melania, 489, 209—2, 3
Myalina, 393, 153—9
Prionocyclus, 593, 247—3–5

Y

yabei, Mizzia, 302—2
yandelli, Amplexus, 93, 29—11–13
yokoyamai, Sigmomorphina, 32
youngianus, Productus, 349
yurnagunensis, Lepidocyclina, 47, 13—9, 10
yvanii, Trochus, 453

Z

zacatecanum, Haploceras, 585, 241—1, 2
zaphrentoides, Cyathophyllum, 85
zitteli, Goniopygus, 226, 88—19, 20: 89—22, 23
Leptomitus, 51
Trochocyathus, 121, 45—8–10